POWER

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A Bigger and Brighter Opportunity

AS the work of the operating engineer broadens and the value of the machinery in his charge increases, the day approaches when the manager will ask him to visit other cities and plants to gather data upon some important installation. This may be a difficult task at first, but by careful preparation one can do it.

When this opportunity comes, get right down to business and begin by reading up on the subject involved. Then your interest will be larger and you can ask intelligent questions when you get on the firing line.

Buy a serviceable loose-leaf book—you can get one for about a dollar—and put a medium-hard pencil or two and an eraser in your pocket. In the front of the book write the leading questions you mean to ask, numbering each to save the time of the man you interview when you put down his replies. Pretty homely advice? Surely, but then you won't come back with half your points overlooked.

Put several strong manila envelopes in your grip to hold any loose material. Collect enough live data to make your report thorough.

If you are a photographer, ask permission to take a picture of any apparatus, etc., that appeals to you.

Gather all the latest publicity matter bearing upon your subject. Ask if a description of the plant has ever been published. Buy the local newspapers and get the atmosphere of the place. Make a list of similar representative installations elsewhere, and aim to visit them enroute.

When you get home, having put down in your loose-leaf book under the proper headings all the business odds and ends of your trip, ask the Old Man to let you either dictate your report or have a typewritten copy made, and don't forget to keep a carbon copy yourself.

Never mind the literary style, just give the plain facts in straightforward order. Write your report while every impression is fresh and sign your name. Draft your report roughly on the way home.

If you work for a house that is worth while, you will be expected to travel in unpretentious comfort. Get a room at a favorably known hotel, and have three square meals a day. Travel in a parlor car on long trips; you can keep cleaner, and often get in touch with people that will benefit you if you sustain that personal reserve which demands the respect of all experienced travelers. But cut out the luxuries!

When you get home, itemize your expense account so that it can be audited easily. Every hour you are away, you personally represent your employer. Act for his interest all the time; it will pay in the long run.

Many times a trip is better than a post-graduate course to the man who takes it with his eyes open. When you hear the call of the Old Man, don't forget for a minute that it spells Opportunity.

It is a chance to become a bigger man and get away from the routine work. Other engineers have done it, are doing it; why not you?

Hydraulic Excavation at Panama

By Fred H. Colvin

An interesting pumping plant and dredging equipment used to remove the loam overlying the rock near the Pacific entrance of the canal.

One of the interesting power plants in the Panama Canal zone was that used for the hydraulic excavating on the Pacific end between the Miraflores lock and the Pacific entrance of the canal.

Time being an important element and it being impossible to assemble a sufficiently large dredging plant to complete this section within the time limit fixed, it was decided to install a hydraulic excavating plant as the most expeditious and cheapest means of handling the loam overlying the rock. An additional advantage was the utilization of the material removed for reclaiming the swamp land along the line of the canal and belonging to the canal commission.

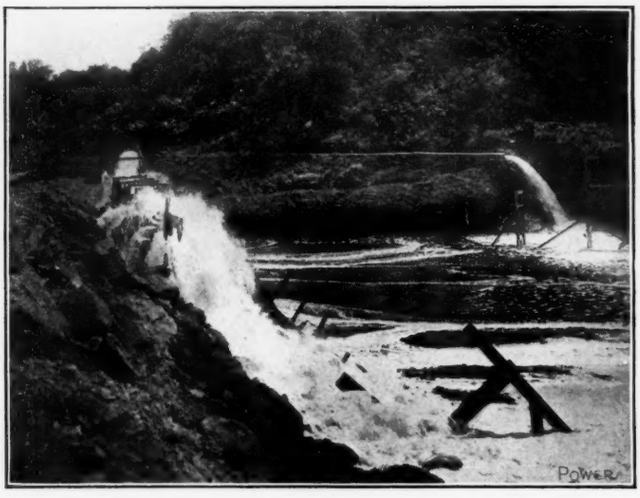


FIG. 1. DISCHARGE IN HYDRAULIC FILL AT COCOLI DAM

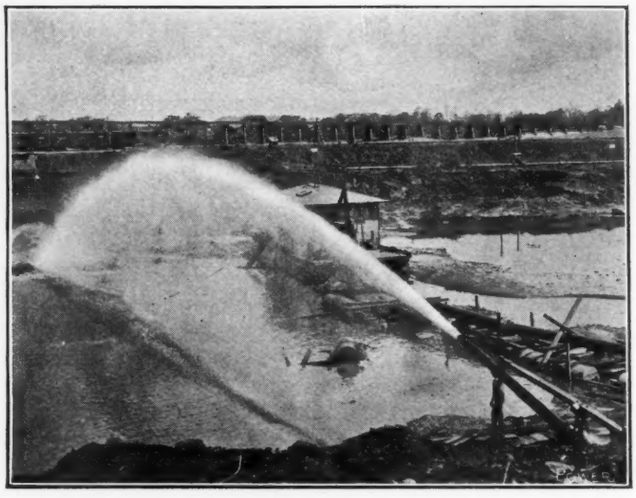


FIG. 2. ONE OF THE MONITORS AT WORK

By using a water jet under pressure, the earth overlying the rock was washed into sumps or low spots where centrifugal dredging pumps elevated and conveyed the material through flumes to the desired point of discharge. A central pumping station, shown in Figs. 5 and 6, was located on the west bank of the canal in the center of the area to be excavated. There were installed four Worthington, horizontal triple-expansion pumping engines with steam cylinders 19, 30 and 50 in., water cylinders 24½ in., and a 24 in. stroke. The condensers were of the surface type and each was provided with a 12 and 20 by 24-in. vacuum pump.

Steam was supplied by four Babcock & Wilcox water-tube boilers arranged in batteries of two. They were oil fired from two steel tanks of 2000 bbl. capacity, erected on a hill for gravity feed to the burners.

The pressure line running from the pumping station was 3600 ft. long, made up of 2000 ft. of 40-in. and 800 ft. of 32-in. lock joint pipe, and another 800 ft. of 24-in. spiral riveted pipe. The main was provided with valves and tees suitably located for connecting branch lines leading to the nozzles or monitors.

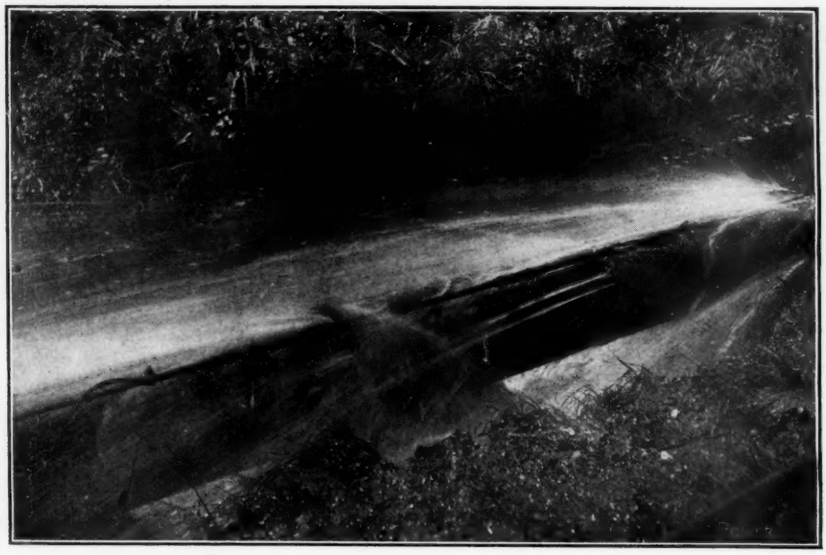


FIG. 3. ONE OF THE BAD SPOTS IN THE LINE

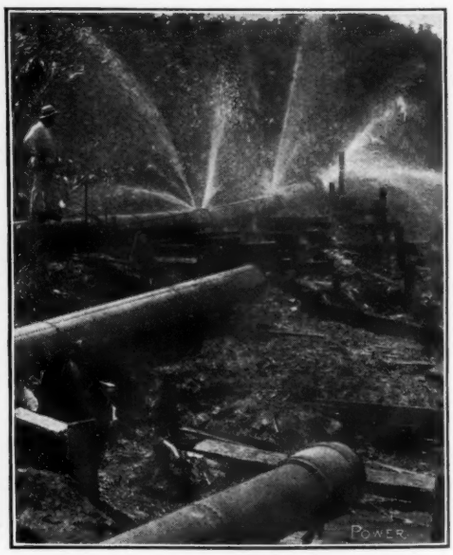


FIG. 4. MORE OF THE LEAKAGE ENCOUNTERED

The branch lines were of 16-in. spiral riveted pipe laid in groups of three so that two monitors might be continued at work while the third was being changed.

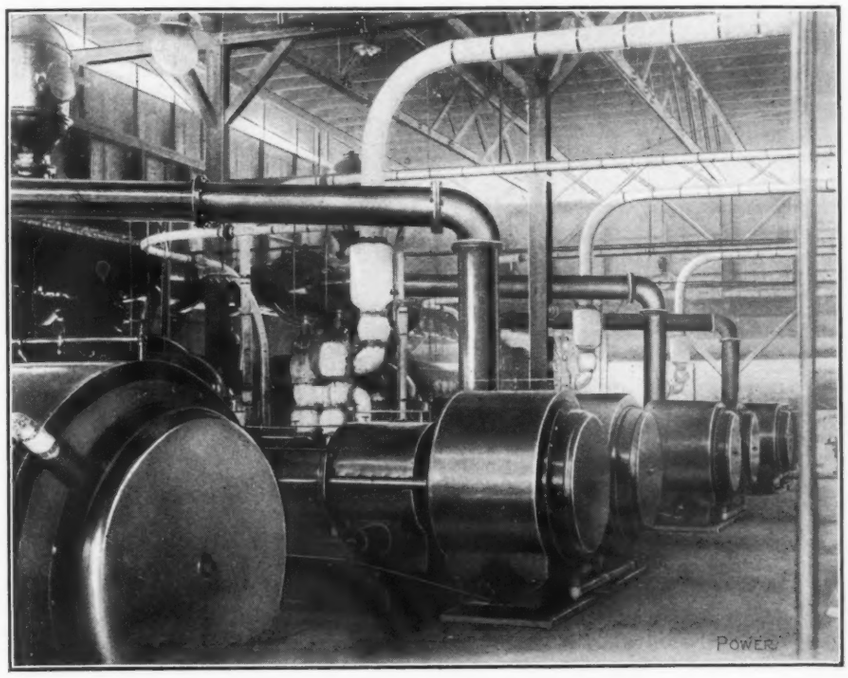


FIG. 5. CENTRAL PUMPING STATION AT AGUA DULCE

The monitors were fitted with special deflecting nozzles.

There were several dredges, each equipped with three 18-in. single-reduction centrifugal pumps, directly connected to a 655-hp. induction motor. These pumps, motors and auxiliaries were mounted on reinforced concrete barges specially designed and constructed for this purpose. After the removal of the earth overlying the rock by the hydraulic process, the rock was excavated by steam shovels.

Fig. 6 shows the pumping station under erection. The pumping engines and piping were first put in place and the station built around them.

As the pumping pressure was 125 lb. per sq.in., it was not easy to keep the lines tight, due to the settling of the earth and the strain put upon the riveted piping. Fig. 3 shows what happened in one of the bad places and the means taken for holding the pipe together so that the work could go on until repairs could be made. Fig. 4 is another view showing somewhat similar conditions and giving an idea of the leakage encountered.

Fig. 1 shows the discharge into the hydraulic fill of Cocoli dam, the same method of filling being employed at the large Gatun dam at the other end of the canal. One of the monitors is shown at work in Fig. 2, the nozzle being about 6 in. in diameter. These monitors could be swung easily into any desired position to wash the earth down into the sump from which it was readily handled by the dredging pumps. One of the concrete barges may be readily seen behind the stream from the nozzle. An iron grating over the end of the suction pipe kept out sticks and stones which would interfere with the working of the pump, but occasionally débris would accumulate across the grating to such an extent that it was necessary for a colored laborer, usually in his birthday suit, to dive into the muddy water and remove the obstructions. After seeking the consolation of a convenient shower bath he awaited the next call of duty.

The whole plant made an interesting installation but has now become obsolete as the earth has been removed and the steam shovels are at work on the underlying rock.

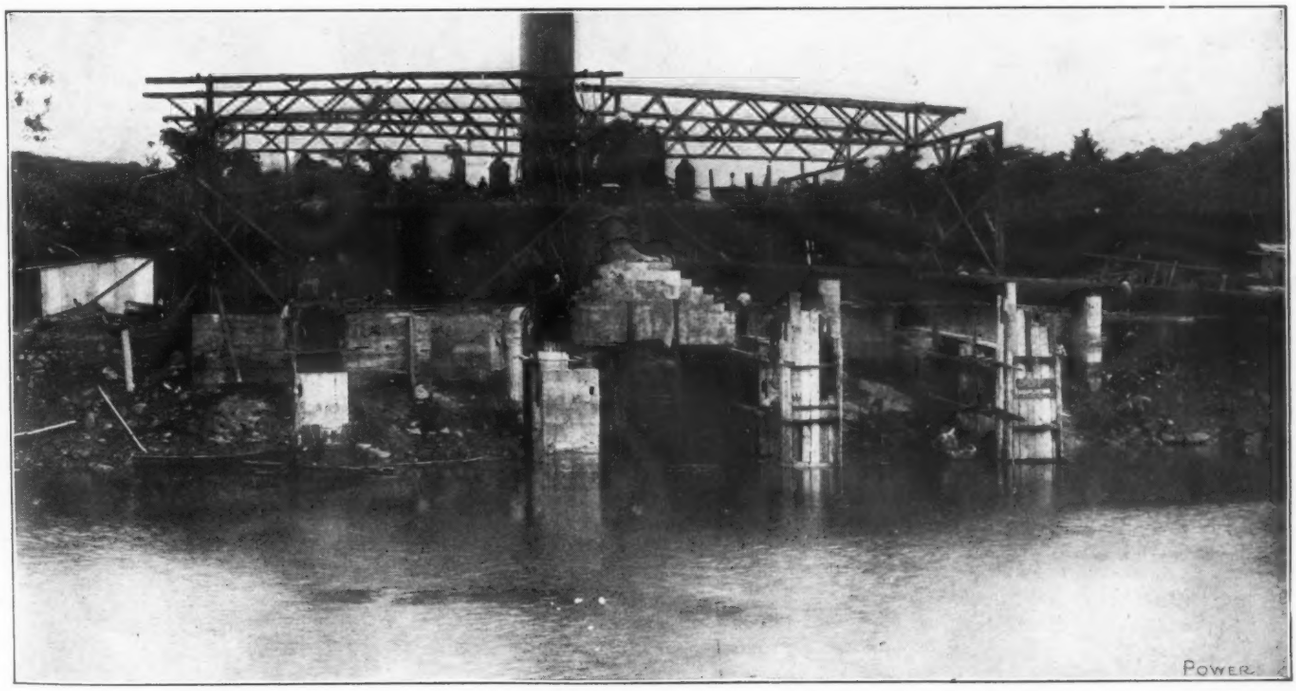


FIG. 6. PUMPING STATION UNDER ERECTION

A Large Pumping Engine

By C. W. Allcorn

Wheeling, W. Va., has just added to its water-works a new pumping engine having a capacity of 20,000,000 gal. per 24 hr. It is a vertical triple-expansion engine of the crank and flywheel type, having 42-, 74- and 110-in. steam cylinders and a 72-in. stroke. The low-pressure cylinder is the largest ever used on a pumping engine; its piston is shown in Fig. 2.

The steam cylinders are supported on double A-frames, one side resting on the water ends and the other on a pier. The cylinders are steam jacketed; the steam from the high- and intermediate-pressure cylinder jackets being tapped into the second receiver and utilized in the low-pressure cylinder. The first and second receivers are 5½x8½ ft. and 7½x9 ft., respectively, and are mounted on the engine frame in the space between the cylinders. A steam pressure of 110 lb. is employed, although the engine is designed for 125 lb. and a 27-in. vacuum. Both steam and exhaust valves on the high-pressure cylinders and the steam valves of the intermediate cylinders are of the Corliss type. The exhaust valves of the intermediate, and both the steam and exhaust of the low-pressure cylinder are cam-operated poppet valves. The steam and exhaust valves are operated by separate eccentrics mounted on a lay-shaft and driven by drag cranks and connecting rods on each end of the 27-in. main crankshaft. A flyball governor controls the high-pressure cutoff, but has a rod attached by means of which the speed can be adjusted by hand while running. The intermediate-pressure cutoff is hand controlled while the low-pressure valves are definitely set and not adjustable while running. The engine runs a little over 18 r.p.m. or at a piston speed of 220 ft. per min. The two flywheels weigh 90 tons. A surface condenser is provided, which receives its cooling water from a bypass in the discharge line. The condenser pump is driven direct from an arm on the low-pressure plunger rod. A jet condenser is to be installed to be used when repairing the surface condenser.

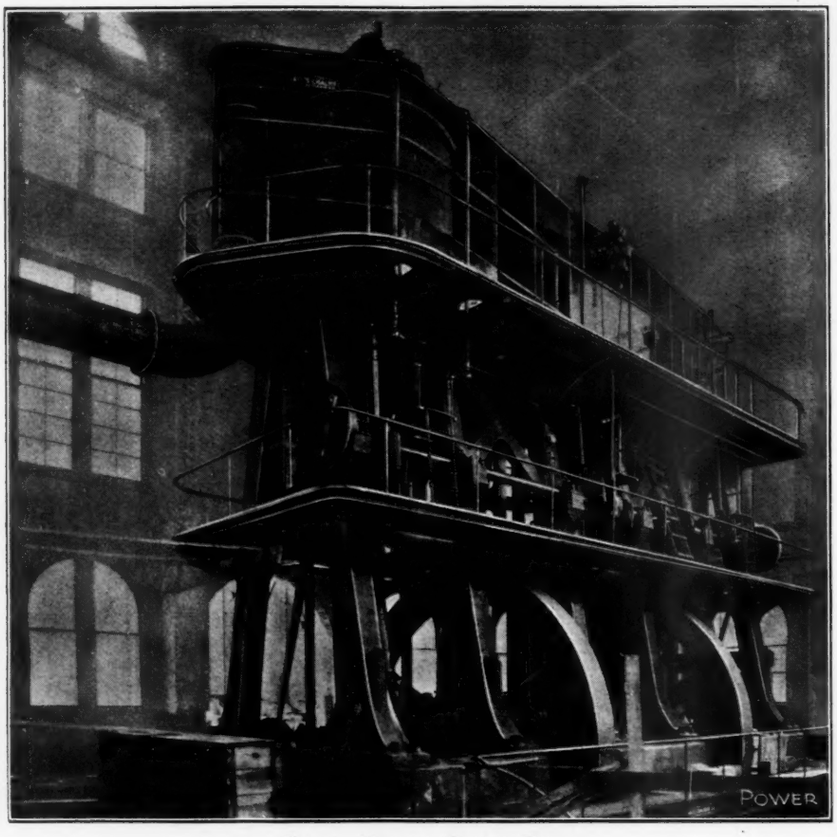


Fig. 1. View of Steam End

The pumps are of the single-acting outside-packed plunger type and are located directly under the steam cylinders. The plungers are 33 in. in diameter and each has its cast-steel crosshead with four distance rods extending to the engine crosshead, thereby deriving direct motion from the steam piston. The valve chambers are 72 in. in diameter, and the valve decks 79 in., containing in all 1116 valves. The valves are of the weighted type, 4 in. in diameter, and are arranged 186 in each deck. Located at the bottom of the pit which is 46 ft. from the engine floor is a six-basket 36-in. Lagonda strainer.

The pump gets its water direct from the Ohio River and pumps it through two miles of 36-in. pipe to the reservoir against a static head of about 250 ft.

The distance from the top of the steam end to the base of the water end is 84 ft. 8 in. A galley is placed at the pump-valve chambers and one above it gives access to the air pump and pump plungers. On the engine there are two galleries; the lower giving access to the crosshead eccentrics, etc., and the upper for inspection of the valve-gears, lubricator, and for applying an indicator motion. A platform at the top of the cylinders is arranged for the inspection of the valves and the receivers. The engine was built by the Allis-Chalmers Co.

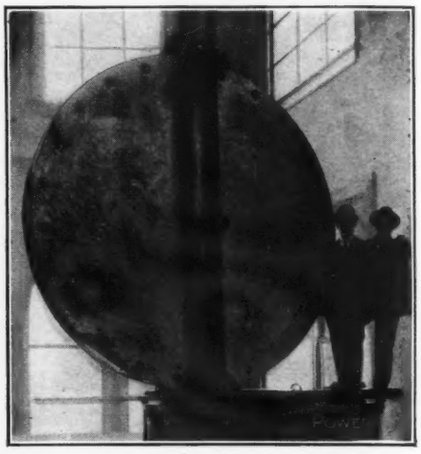


Fig. 2. Low-pressure Piston

Gold Metal for Safeguarding Life

The Allgemeine Electricitäts Gesellschaft. of Berlin, has cabled President Arthur Williams, of the American Museum of Safety, that the Rathenau gold medal has been placed at the disposal of the museum for award annually for the best device or process for safeguarding life and limb or promoting health in the electrical industry.

Competition is open to every country, the only condition being that the device or process must be exhibited at the American Museum of Safety, New York City.

The Rathenau medal is well known in Europe. It was presented to Dr. Emil Rathenau, president and founder of the Allgemeine Electricitäts Gesellschaft, on his seventieth birthday, with the felicitations of the Kaiser for his services in the field of electro-technics and having introduced incandescent lighting into Germany. One medal will be cast each year from the original die for the museum to award.

The water power of the River Rhone at a point 280 miles from Paris is to be used in supplying that city with electric light and power. Plans have been completed for the dam and power plant.

Limitations of Reducing Wheels

By Julian C. Smallwood*

A series of tests made with a special tester devised by the author upon the drum motion produced by various reducing wheels. The errors and limitations of reducing wheels are pointed out and some general operating rules given to insure accuracy.

*Associate Professor of Experimental Engineering, Syracuse University.

In the Aug. 20 issue the writer presented the results of tests on engine indicators showing the distortion of the drum motion at all parts of the stroke due to the stretch of the cord. The instruments tested were operated under various conditions such as might be met in practice when an accurate reducing motion as of the pantagraph or link type is used. From the results it appeared that the diagram obtained by the ordinary indicator may be seriously in error, both as to mean effective pressure and events of the stroke, when operated at speeds for which it is not adapted and under certain other adverse conditions.

Link-reducing motions, however, have been largely supplanted by reducing wheels on account of the latters' ready adaptability. To complete the drum-motion investigation, then, tests of this type of reducing motion are necessary. Since the cord used with this device is longer and the mass moved by the cord is greater than with link motions, the stretch of the cord and the inertia of the wheel may cause appreciable error.

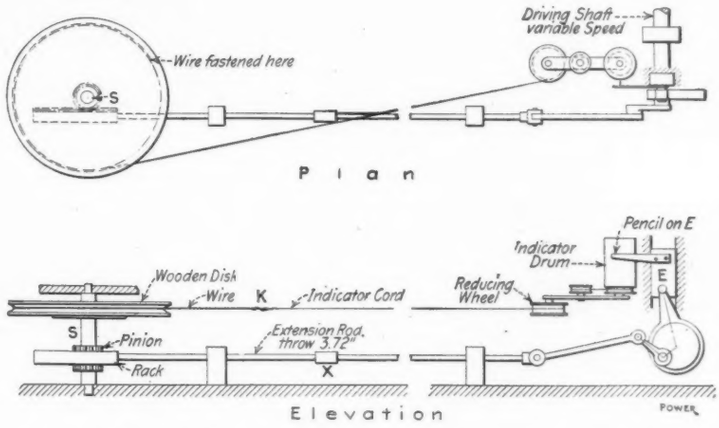


FIG. 1. DRUM-MOTION TESTER WITH ATTACHMENT FOR LONG STROKES

To test the drum motion produced by various reducing wheels, an addition was made to the drum-motion tester devised by the author and previously described. The apparatus is shown diagrammatically in Fig. 1, and as photographed in Fig. 2.

The drum-motion tester, as originally used, carried a bracket at *X*, to which the indicator cord was fastened, thus duplicating the condition of a link-reducing motion. As the motion of the pencil point carried on the vertically traveling crosshead *E* is exactly proportional to the motion of the bracket, the diagram produced by the tester is one of crosshead motion shown vertically against drum motion horizontally. When the drum and crosshead motions are exactly proportional the diagram is a straight inclined line and there is no error. The stretch of the cord, however, causes lack of proportionality and a closed curve results. The departure of any point on this curve from the straight line adjoining its uppermost and lowest points marks the error of the drum motion. Fig. 3 shows an error diagram and is self-explanatory.

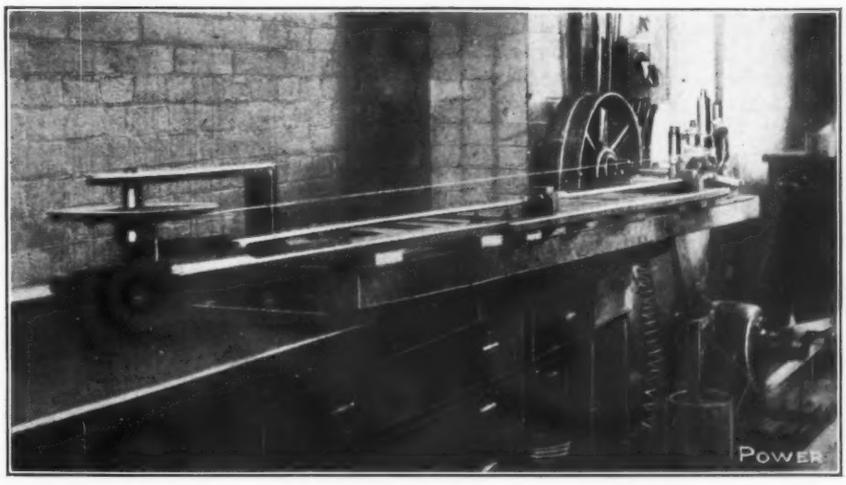


FIG. 2. THE DRUM-MOTION TESTER AS SET UP FOR A TEST

To adapt this device to reducing wheels, a bracket, or some equivalent attachment is necessary with a long stroke to duplicate an engine crosshead motion; and, to make the apparatus cover all operating conditions, the stroke should admit variation. This is conveniently accomplished by coupling an extension rod to the motion tester, carrying at its outer end a rack meshing with a pinion on a vertical shaft. This shaft *S*, Fig. 1, carries a wooden disk which was replacable by others of different diameters. When the rack is reciprocated, the disk is given an oscillating motion. An extension of the indicator cord from the reducing wheel being fastened to a point on the circumference of the disk, the cord will be reciprocated through a stroke the length of which depends upon the diameter of the disk. By using different disks, a reducing wheel may thus be operated through any desired stroke.

The apparatus was made with great care to avoid back lash and other imperfections. The rack and pinion were cut with involute teeth and were held closely in mesh by an adjustable roller at the back of the rack. The wooden disks were turned on the shaft to make them perfectly concentric and were held by a 5-in. faceplate which also located centers. For the long strokes the effort of the reducing wheel spring was partly balanced by another spring working oppositely on the disk. The pulley driving the apparatus was large enough to act as a flywheel and make the speed of rotation uniform, as a tachometer held to the pulley shaft gave steady indications. A calibrated tachometer was used for all speeds above 100 r.p.m.

In the operation of a reducing wheel the same forces are set up as in the indicator drum discussed in the previous article. These are spring tension, friction and force due to inertia. Since the drum and wheel masses are connected

by a short cord having inconsiderable stretch, they may be regarded as one mass producing a single inertia effect. Likewise, the two springs may be considered as exerting a single force. In Fig. 4, the component forces are shown as they are felt at the cord at three parts of each forward and return stroke. The arrows represent roughly by their length

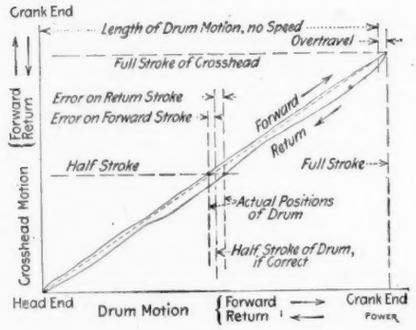


FIG. 3. DRUM-MOTION TESTER DIAGRAM. DOTTED LINE REPRESENTS CORRECT MOTION

the comparative magnitude of the forces.

At the beginning of the forward stroke, the cord exerts a maximum force in overcoming friction, inertia and spring tension; but as most of the cord is wound on the wheel, its stretch and the consequent lag of the drum are inappreciable.

As the crosshead advances the length of cord free to stretch becomes greater, but, as the velocity of the moving parts approaches its maximum in the neighborhood of midstroke, the effect of inertia is to lessen the force exerted by the cord and therefore its stretch. This continues throughout the forward stroke; as the length of the cord increases its stress decreases, and the net effect is to maintain a reasonably uniform total stretch and consequently to give a correct drum motion. On the return stroke, however, the spring tension is required to accelerate the wheel sufficiently so that the cord does not slacken, and it must do this not only against inertia, but against the frictional resistance.

As the friction is large, the spring may not be able to do this at a rate equal to that at which the crosshead is being accelerated, particularly at the beginning of the stroke, as here the acceleration is greatest. The stretch of the cord is therefore released at the beginning of the return stroke, if not entirely slackened, as evidenced by whipping. Beyond midstroke, the moving parts of the wheel have gained sufficient momentum to draw up the cord again, and this momentum keeps it taut to the end of the return stroke. Under ordinary circumstances, then, a marked distortion of the drum motion may be expected only through the return stroke and greatest at its beginning.

Obviously the length of the cord free to stretch, i.e., that part of it not wrapped around the wheel, has a decided influence upon the correctness of the motion. In practice this length at its minimum and maximum is determined by the engine stroke. Normally, at the head end, the length of cord free to stretch is about equal to the stroke, and at the crank end twice as long.

The experiments were made, except where specifically noted, with a length of cord to duplicate this condition. This was accomplished by tying the indicator cord, when adjusted to the desired length, to a piece of stranded wire which was then connected to the disk, Fig. 1. The wire being practically inextensible, the effect was to reciprocate the cord through the desired lengths as by an engine crosshead at the point K.

The cord used was of medium grade, unless otherwise noted, showing a stretch of 0.02 in. per foot per pound when stressed between 1 and 4 lb.

The total spring tension referred to the line of the cord at the crank-end dead center of motion was recorded in each series of tests. This was found by fastening the cord to a spring balance and drawing it slowly past the dead center so that the total tension in the cord could be observed at the moment of passing. This tension is equal to the force of the spring S plus friction F. The cord was then allowed to rewind on the wheel, and another reading taken upon passing the dead center in the reverse direction. The value so found equals the spring tension minus friction. Then, using numerical values,

$$S + F = 48\ oz.$$
$$S - F = 24\ oz.$$

Adding,

$$2S = 72\ oz.$$
$$S = 36\ oz.$$

and

$$F = 48 - 36 = 12\ oz.$$

or 33 per cent. of the spring force.

In general the friction is a fixed percentage of the other forces, and as it imposes a serious limitation to successful operation, the importance of this determination should be emphasized.

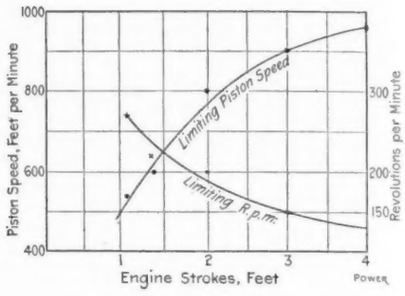


FIG. 5. CURVES SHOWING HIGHEST SPEEDS AT DIFFERENT ENGINE STROKES; WHEEL NO. 1, INDICATOR "C"

Four wheels were tested after being put in best working order by an expert instrument maker. They were run with indicators A and C, described in the article on drum motion and a third indicator D. Brief descriptions follow in which the wheel used for adjusting the motion to different engine strokes is referred to as the stroke wheel, and the one to which is attached the cord from the crosshead as the main wheel:

Wheel No. 1, used with indicator C. Spiral (clock) spring. Spring barrel carries the stroke wheel. Stroke wheel connected to main wheel by a short cord.

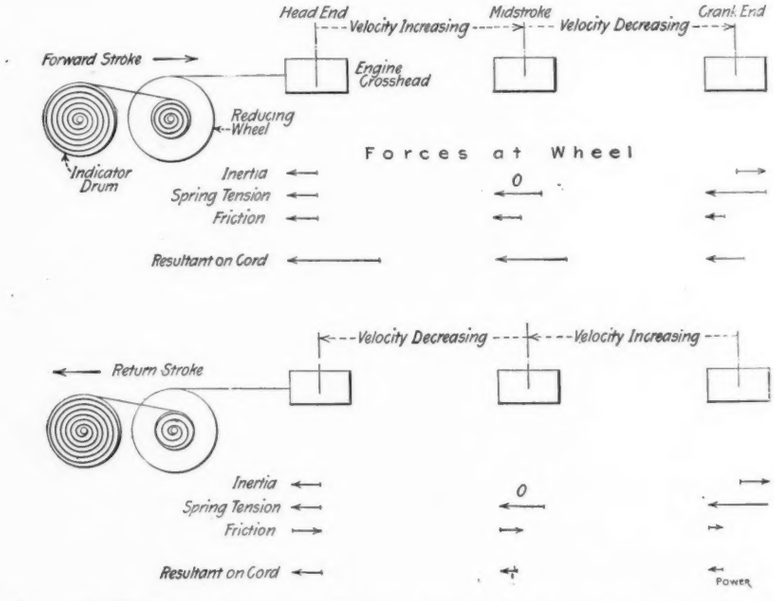


FIG. 4. FORCES ON A REDUCING WHEEL AND INDICATOR DRUM DURING OPERATION

Total friction of wheels and drum, 20 per cent. of the other forces.

Wheel No. 2, used with indicator C. Spiral spring. Same arrangement of wheels as No. 1 except that the main and stroke wheels are connected by gears. Friction, 50 per cent.

Wheel No. 3, used with indicator A. Helical spring. Same arrangement of wheels as No. 2. Ball bearings. Friction, 33 per cent.

Wheel No. 4, used with indicator D. Spiral spring. Stroke and main wheels are combined in a single small light wheel whose shaft is geared to the indicator drum. Light spring behind wheel, but

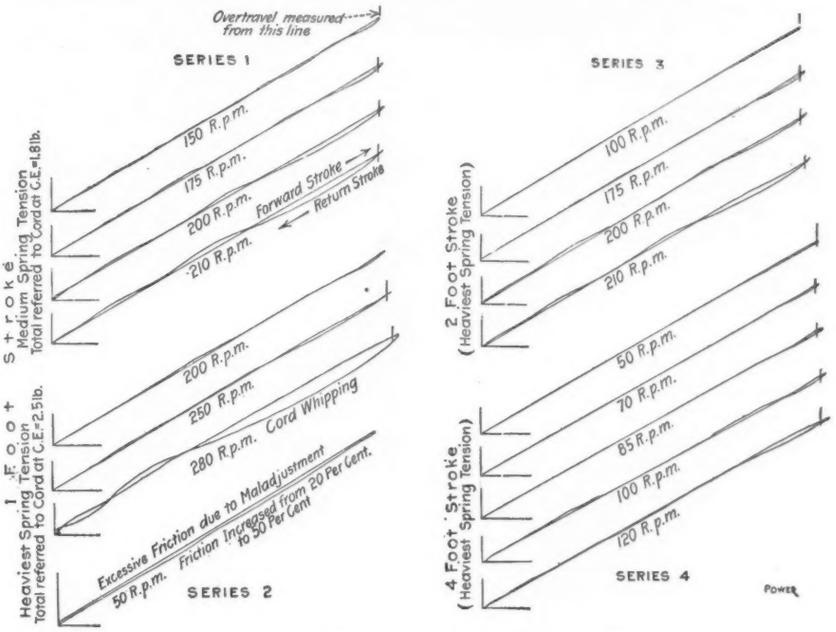


CHART 1, WHEEL NO. 2, INDICATOR "C"

drum spring furnishes the greater force to return the parts. Drum, 2 in. in diameter and comparatively heavy. Friction, 23 per cent.

For the presented results from the first three wheels, the drum-spring tension was kept constant for both indicators, and equal to 2¼ lb. at midstroke. This tension was found by previous tests enough to accelerate the mass of the drum only; the acceleration of the reducing-wheel masses was taken care of by varying the tension of its spring. Some tests were made with greater drum-spring tensions, but the results are not presented for reasons to be noted later. At each engine stroke, drum-motion tester diagrams were taken at increasing speeds of revolution until the effect of inertia was apparent to the eye through the whipping of the indicator cord, which condition would not be tolerated in good practice.

The results from wheel No. 1 and indicator C are such as to be met in the operation of good, if not equal to the best, apparatus, and are therefore presented more fully than the others. Tests were made of this combination at 12-, 16-, 24-, 36- and 48-in. engine strokes with many variations of the operating conditions, quality and lengths of cord and the like; but only the representative results are presented. These are given by Chart 1, the diagrams being the same as that indicated in Fig. 3, but closely spaced for convenience. For a 12-in. stroke, the motion is correct up to 150 r.p.m. when a medium wheel-spring tension is used (Series 1). At this speed there is a slight lag at the beginning of the return stroke which becomes more pronounced at higher speeds until at 200 r.p.m. there are considerable errors during most of the return stroke. This accords with the reasoning in the preliminary analysis, that so much of the spring tension is absorbed in overcoming friction that enough is not left to promptly accelerate the wheel after passing the crank-end dead center.

Increasing the wheel-spring tension, as shown by Series 2, enables the wheel to be run at higher speed; the limit is reached at 280 r.p.m., or a piston speed of 560 ft. per minute with the total spring tension, referred to the line of the cord, 2.5 lb.

The other diagrams of Chart 1 were obtained with this same total tension, the highest obtainable without increasing that of the drum spring. A study of the chart brings out the following subjects for discussion:

First, the overtravel of the drum is small at both ends of the stroke.

Second, the distortion of the return-stroke motion is very marked and follows a characteristic wave. Notice that the forward motion is in all cases very closely true.

Third, the piston speeds producing whipping and therefore limiting the operation of the wheel, are much greater at the longer strokes.

The first effect is largely due to friction which helps the springs to check the velocity of the wheel at the end of the forward stroke. Much overtravel at the crank end would be evidenced by whipping of the cord. For instance, if the drum motion were 4 in. and the engine stroke 24 in., an overtravel of the drum of ⅛ in. would mean a slackening of the cord six times that amount, or ¾ in., since any distortion of the drum motion is multiplied at the wheel by the ratio of the motions. This is enough to cause whipping unless the cord is very stretchable. At the head end the overtravel is subdued not only by friction but by the positive resistance of the cord, the stretch of which is a minimum at this end because of its reduced length.

The second effect is due not only to friction, but is increased because an indicator cord varies very considerably in length for changes of stress below 1 lb., although above that amount the stretch

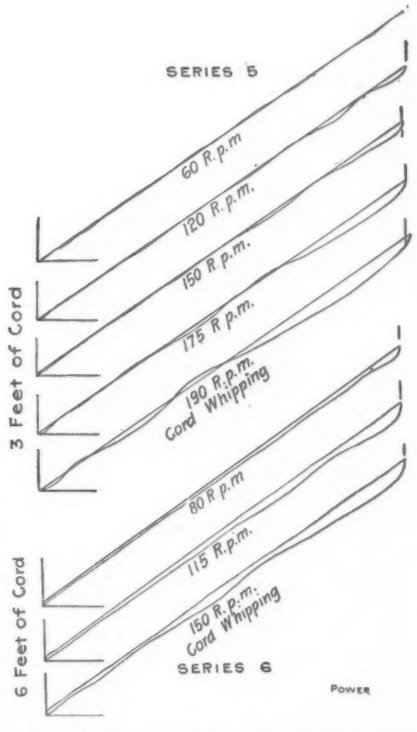


CHART 2, WHEEL NO. 2, INDICATOR "C"

is comparatively small and uniform with increasing stress. Also the cord will contract markedly when the stress reduces to zero, and sometimes has been observed to continue contracting after the stress was entirely removed. If the frictional resistance to motion of the reducing wheel prevents the spring from properly accelerating it upon the return stroke, the crosshead motion gains upon the wheel motion, thus reducing the stress in the cord, perhaps to only a few ounces. The cord accommodates itself to this

change in length because it contracts markedly at low stresses, and not until the distortion of the drum motion is quite pronounced is the speed of contraction exceeded by the crosshead speed, as evidenced by whipping.

The lag of the drum motion just after passing the crank-end dead center is only momentary at moderate speeds because the force required to accelerate the wheel is a maximum at dead center; when it has once started upon the return stroke less force is needed to continue the motion and this the spring is able to deliver. At higher speeds the action of the spring is further delayed, so that the late acquired momentum of the parts causes them to overshoot the mark and fetch up

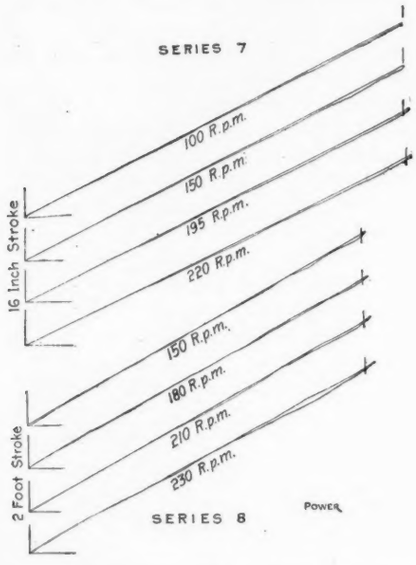


CHART 3, WHEEL NO. 3, INDICATOR "A"

against the positive resistance of the cord, resulting in the wave previously noted.

The third effect follows from the limitations caused by inertia. It is shown more clearly by the curve, Fig. 5, of highest piston speeds plotted against engine strokes. The speeds plotted were those observed to cause a slight vibration of the cord; the highest spring tension was used in each case. The effect is explained by the fact that at a given piston speed the oscillations per minute of the wheel are greater, the smaller the engine stroke, and therefore the effect of inertia is greater with the small strokes. Obviously, it is more difficult to oscillate a mass moving at a fixed average speed, the more frequent are the oscillations. This also follows from the mathematical value for the force required to accelerate a reducing wheel at the ends of the stroke (assuming harmonic motion) which may be expressed as follows:

$$A = W \times L \times N^2 \times a \text{ constant}$$

or

$$A = W \times LN \times N \times a \text{ constant}$$

in which

A = Force of acceleration referred to the cord;
W = Weight of moving parts referred to the cord;
L = Length of engine stroke;
N = Revolutions per minute.

This may be interpreted "Inertia of a reducing wheel varies directly with the stroke and the square of the r.p.m.," or "directly with the stroke and the piston speed." It follows that wheels arranged as are Nos. 1, 2 and 3 will operate less successfully at the shorter strokes.

This analysis does not consider the inertia of the indicator drum. The throw of the drum is practically constant at all strokes, so the force required to accelerate it at the ends of the stroke is

$$a = w \times l \times N^2 \times a \text{ constant}$$

or

$$a = w \times N^2 \times a \text{ constant}$$

in which w is the weight of the drum and l its stroke. Thus, a varies with the square of the r.p.m. only.

The total force of acceleration of drum and wheel is the sum of these forces a

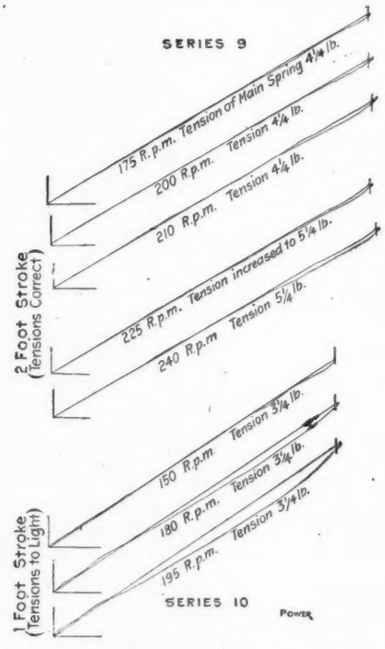

SERIES 9
175 R.p.m. Tension of Main Spring 4¼ lb.
200 R.p.m. Tension 4¼ lb.
210 R.p.m. Tension 4¼ lb.
2 Foot Stroke (Tensions Correct)
225 R.p.m. Tension increased to 5¼ lb.
240 R.p.m Tension 5¼ lb.
150 R.p.m. Tension 3¼ lb.
180 R.p.m. Tension 3¼ lb.
195 R.p.m. Tension 3¼ lb.
1 Foot Stroke (Tensions to Light)
SERIES 10
Power

CHART 4, WHEEL NO. 4, INDICATOR "D"

and A, but as the drum spring is strong enough to meet the drum inertia at the highest speed of oscillation possible with the usual reducing wheel, the force a generally need not be considered.

If the wheel velocities are low so that inertia is not material, the frictional resistance to motion, if excessive, may cause a material lag of the drum behind its correct position throughout both strokes, since it effects a stretch of the cord upon the forward and a slackening upon the return stroke. This is shown by the lowest diagram of Series 2, Chart 1, the additional friction being introduced by a maladjustment of the wheel which might easily be made in practice. The thumbscrew holding the main wheel upon its spindle was turned a shade too far so that it cramped the bearing.

If the variation of stress in the cord is the same for different engine strokes, the distortion of the drum motion is the same. This is because any error in the motion of the wheel is reduced at the drum in the ratio of the drum travel to the wheel travel. For example, if the stresses are the same, the stretch of the cord on a 4-ft. engine stroke is double that of a 2-ft. stroke, since the cord is twice as long, but as the resulting drum distortion is one-twelfth of the stretch in the one case (drum stroke being equal to 4 in.) and one-sixth in the other, the effect is the same.

The results upon the other wheels are therefore presented for the short strokes only (although others were made), and these, it must be remembered, represent adverse conditions.

Wheel No. 2, although the same in general arrangement as No. 1, ran with excessive friction, partly because of the gears used, but mainly because of the arrangement for guiding the cord. On this account it could be run at no higher piston speed than 470 ft. per minute, 175 r.p.m., at a stroke of 16 in., without marked inertia effects. Chart 2 shows that the errors are very considerable, particularly when a long cord is used. It is noticeable that whipping occurred at a lower speed with the long cord; this is due to its weight overcoming the tendency to contract under the reduced external force. Noticeable, also, is that practically no overtravel occurs at any of the speeds except 190 r.p.m.

This wheel could be run at a piston speed of 720 ft. per minute at a 4-ft. stroke. At this speed, using a cord of 8 ft. maximum length, the errors were very much the same as the 80 r.p.m. diagram, Series 6, Chart 2.

The spiral or clock type spring increases its tension but little upon being wound. To accommodate a reducing wheel to higher piston speeds, either its friction must be decreased or its spring tension in the out position increased. The helical type spring is more readily adaptable to the latter requirement as its tension increases more rapidly with twist. From this it was foreseen that a wheel having such a spring would be more accurate at higher piston speeds, and accordingly Wheel No. 3 was tested. The results, Chart 3, show comparatively little error up to 200 r.p.m. or a piston speed of 800 ft. per minute at a 2-ft. stroke, and that it could be run as high as 920 ft. This wheel was new, which probably accounts for the distortion shown by Series 7 for the 16-in. stroke. The friction of the gears became less after a little use, so that Series 8 shows much more accurate results.

This wheel was driven by a fine fish-line, instead of indicator cord, which

was furnished by the wheel makers. The pitch of the cord-guiding device was such that regular indicator cord could not be used. The resilience and consequent stretch of a high-grade fishline, however, are not desirable for indicator work; and this line was found to be the poorest of many samples tested, having a stretch of 0.04 in. per foot per pound between 1 and 4 lb. But for this, Wheel No. 3 would have yielded still better results.

Wheel No. 4 showed different characteristics from the others, the limit to operation being controlled by the speed of engine revolution and not materially by the engine stroke, due to the peculiar combination of wheel and drum, for the indicator drum itself took the place of the usual wheel-spring barrel. The combined stroke and main wheel was so light and small that its inertia was insignificant compared to that of the drum which was particularly large and heavy. This combination gave unexpectedly good results, Chart 4, as it showed a nearly correct motion at a piston speed of 900 ft. per minute and a 2-ft. stroke (see Series 9, diagram at 225 r.p.m.) and could be run as high as 960 ft. This wheel's merit is due to the spring actuating both drum and wheel being large and strong, and to lack of friction, the gears and bearings running freely. The motion may be very erroneous, however, if the spring tension is too light, as shown by Series 10 for a 12-in. stroke. With the heavy tension and this stroke, the limiting speed of revolution was practically the same as with the 2-ft. stroke, and the errors were the same at the same speeds.

A general conclusion from the investigation is that the reducing wheel is reasonably accurate on short engine strokes and moderate piston speeds, and on long engine strokes at all usual piston speeds, *if properly designed to avoid friction*. The drum motion resulting from its use has its maximum error, when the friction is small, at a part of the stroke where usually it would affect the indicator diagram little if any, namely, at the beginning of the return stroke where either the steam line on the crank end or the exhaust line on the head-end diagram is described. As these lines are generally horizontal, or nearly so, errors upon them would not appear, except at their ends.

How to judge when the conditions of operation are such as to cause material distortion, cannot well be foretold unless the given wheel is tested by some such device as the drum-motion tester herein described. Overtravel of the drum motion does not indicate error with reducing wheels, as it is always small, exists for even low speeds when the motion is actually accurate, and may not exist at all when the friction is such as to cause large error, as shown by Chart 2. A vibrating cord should not be relied upon as a danger signal, for a speed causing large inertia errors will often not slacken the cord on account of its property to contract greatly under low values of a diminishing stress. This, however, applies more particularly to the short strokes, as the greater length of cord used otherwise, and its consequent weight, will cause vibration if it is not stressed with a force sufficient to accelerate the wheel.

The general rules to observe in operation are: Keep the wheel-spring tension as high as possible if its ability to accelerate the wheel is doubted. Amply lubricate, with watch oil, all moving parts of both drum and wheel and see that their motion is free from mechanical obstruction. Avoid guide pulleys, as these materially increase the friction, as was shown in the article on drum motion. Use only the best grade of cord, and be sure that it is the best not by trying its stretch with the unaided hand, but by measurement with a spring balance.

A stretchable cord, on account of its ability to contract as well as stretch, may prevent whipping under conditions that would slacken a stiff cord. This, however, is no reason for using it; whether or not the cord whips, the distortion exists, and it is desirable not to conceal the evidence of it.

A deficiency of wheel-spring tension may be corrected by tightening the drum spring to a limited extent only, because the drum spring acts upon the wheel at a mechanical disadvantage on account of the reduction of motion, and therefore has only a small effect to accelerate it. On the other hand, tightening the drum spring increases the reaction on the drum spindle, and therefore the friction to be overcome throughout the stroke, and this may cause even more distortion.

The faults of design of the wheels tested are two: First, the springs are not strong enough at short strokes, and are not properly proportioned in that instead of exerting a slightly increasing force as they are wound, they should furnish a much higher tension at the crank end than the head end. Second, friction is not avoided as much as it might be. This, however, is difficult. Wheel No. 3 has ball bearings, but on account of the gears and an unfortunate arrangement for connecting the stroke wheel to the drum, its friction is above the average. In conclusion, it is hoped that these tests will inspire confidence in the reducing wheel as an instrument of moderate precision and that they may indicate its limits of operation.

Iceland possesses a large amount of power in the shape of waterfalls. Quite recently a French syndicate purchased a large extent of ground in the neighborhood of Thorlakshaven, as well as several large waterfalls situated in the mountain regions in the interior. It is stated that the falls will be able to furnish as much as 200,000 hp.

Measuring Emulsified Oil in Condensation

Ordinarily it is not difficult to detect the presence of free oil in water, since given sufficient time, the oil will make its appearance on the surface. It is not always so easy to detect emulsified oil, which is nearly always present in the condensed exhaust from reciprocating engines, pumps and other apparatus where a good oil separator is not installed in the exhaust-steam line.

The Martin test tube, an instrument specially designed for this purpose, is made of clear glass, except at the bottom, which is opalescent or milky, with a small black dot in the center. The manner of using the instrument is to collect in a glass or cup a sample of the condensate

MEASURING OIL IN CONDENSATE

to be tested, and then taking the tube to a good light from a north exposure, that is, neither direct sunlight nor electric light, but rather to strong, diffused daylight, pour the water slowly into the tube, until the black spot just disappears from view. The graduation on the tube opposite the level of the water will show the amount of oil in emulsion, in grains per U. S. gallon.

The results obtained by these tubes have been repeatedly compared with analyses made by chemists and are reported to be substantially correct. The tubes are sold by the Harrison Safety Boiler Works, of Philadelphia, who report that they have proved very useful in several instances in ferreting out the sources of oil in boiler-feed supplies, in testing the efficiency of different types of oil separators in determining the degree to which different grades of cylinder oil emulsify, etc.

Taking Care of Bearings and Brasses

By J. C. Hawkins

Numerous methods are used by engineers in keying up and taking care of bearings, some of which are just guesswork, especially on crank and wristpin brasses. All bearings must have a little clearance to allow for expansion of the metal as it warms up, but the amount of play is often guessed at, sometimes with disastrous results. It is a good plan to calculate how much a box will be tightened by one turn of the wedge bolt, in driving the key ⅛ in., or by the thickness of a liner, such as is used on the marine type of crankrod.

It is much better to be sure of the adjustments before the start than to have to fight a hot bearing, or shut down and slack up on the wedge bolt later on. Fig. 1 shows the connecting-rod of a high-speed engine. Each wedge bears directly against one brass and is held by two adjusting bolts. To tighten the brasses the top bolt is loosened and the wedge is drawn down by the bottom bolt; the top one is then tightened. Assuming that the wedge has a taper of 10 deg., or 2⅛ in. per ft., and a 1-in. tap bolt with eight threads per in., drawing the wedge down 1 in. will close the brasses

$$2\tfrac{1}{8}\ in. \div 12\ in. = 0.177\ in.$$

One turn of the tap bolt will close the brasses

$$0.177 \div 8 = 0.0221\ in.$$

The cap bolt has a hexagonal head, and turning the screw one section will close the brasses nearly 0.0037 in.

In keying up this type of bearing, if the brasses and pin are in good condition, the writer loosens the top bolt and draws the wedge down tight, then slacks back about 0.004 in. for an 8-in. pin and 0.003 in. for a 4-in. pin, depending on the condition of the pin, the speed of the engine and the load. After the first trial one can usually tell just how much to slack back to get the best results. The wristpin is adjusted in the same way, but is given about 0.001 in. less clearance.

With the crankrod, Fig. 1, the cylinder clearance is not changed by the wear of the stationary brasses. In some rods of

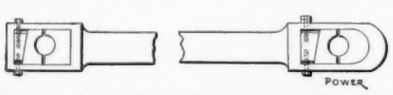


Fig. 1. Rod for High-speed Engine

this type the wedge is placed back of the brass on the crank end, in which case the rod becomes longer with each adjustment, thereby reducing the head-end clearance. This wear is adjusted by placing shims of soft steel between the brass and the end of the slot in the rod on either end, but usually on the crank end.

In Fig. 2 is shown a rod using gibs and a key on the crank end and a wedge and bolts on the crosshead end. The key on the crank end has a taper of ⅜ in. in 1 ft. Driving this wedge 1 in. will close the brasses

$$0.375\ in. \div 12\ in. = 0.0312\ in.$$

In keying up brasses, place a rule across the wedge and gibs and make a mark

Fig. 2. Rod with Gibs, Keys and Wedge Adjusted

with a lead pencil, not with a scriber, which leaves a mark each time and is apt to be misleading. Then drive the key down tight and slack back to give the proper clearance, which would be $\frac{1}{16}$ in., $\frac{3}{32}$ in., or ⅛ in., depending on the size of the pin and the amount of clearance desired.

The inner brass is set against the end of the rod and the brass *A* is held by the strap. The gibs prevent the strap from spreading and in keying up the strap it is drawn further on the rod.

If the key drives all the way down, take it out and make a ⅛-in. steel feather to fit between the key and gib. A soft hammer should be used in driving keys to prevent upsetting the head. In keying up, turn the crank to the back center; this brings the wedges to the most accessible position. If the crankpin is not round, this position will cause the brasses to be adjusted on the largest diameter of the pin. To adjust the wristpin brasses, the crank would have to be at one-half stroke, thus making the top bolt inaccessible.

Fig. 3 shows a marine type of crankrod in which thin liners are used between the

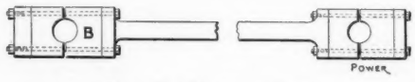


Fig. 3. Marine Rod

brasses. There should be several liners in a set, one or two thick ones and several 0.002 in., 0.004 in. and 0.008 in. in thickness.

In this type of rod the thickness of the liner removed is the amount the brasses are set up. To adjust, loosen the bolt nuts and remove three or four liners, being sure to have the same number on each side. Then put in a piece of soft wire (fuse wire is good) and draw up tight against the pin, but do not spring the boxes. Then slack off and measure the thickness of the wire with a caliper, or, better still, with a micrometer and put in enough liners to make up this thickness plus the desired clearance. These liners should be made with a slot from the bolt-hole to the end so that they can be taken out without removing the bolts.

In some small vertical engines it is impossible to get at the crosshead brasses, in which case the pin is taken out after blocking up the crosshead; the crank is then turned to the end of the down stroke, so that the pin can be fitted to the brasses below the crosshead. In this type of rod the wear of the inner brasses will shorten the rod, which will decrease the crank-end clearance. This is remedied by placing a steel liner between the brass *B* and the end of the rod.

When taking up on the eccentric, the writer usually takes out a thin liner, say 0.003 in., and after tightening up, disconnects the eccentric rod from the valve-gear and moves it sideways, also up and down, to see if it is too tight. It is often necessary to do a little guesswork here, being sure not to take up too much at one time.

In keying up the valve-gear, the bearings are so small that very little clearance is required, and at the same time, an excessive amount in proportion to the size of the pin will do no harm. It is usual to set the brasses up tight, then slack off a little.

To key up the main bearings, the wear is usually taken up by some form of a wedge which is either drawn up or forced down between the quarter-box and frame.

As this bearing is stationary it is best adjusted when the engine is running just enough to make the bearing run quietly. Wear on the back quarter-box will throw the shaft out of alignment with the cylinder, and this will make the crankpin brasses bind and wear one-sided.

Modern engines have "spots" planed on the inside of the frame opposite the crank and parallel to the center line of the cylinder. Caliper between one of these spots and the crank, then turn the crank over until the same point on the disk comes opposite the caliper again. The difference, if any, will show how much the shaft is out of alignment. Then remove the main bearing wedge and push the shaft and back quarter-box ahead with a bar if the engine is small. On a large engine put the crank on the head-end dead center and admit a little steam through the bypass and then place thin liners between the back quarter-box and the frame. The quarter-boxes withstand the thrust of the piston and, therefore, wear very much faster than the bottom box, which only carries the weight of the shaft and wheel.

Any wear of the bottom box can be found by placing a level on the shaft, which will show whether the bearing is down or not. If it is very much out of plumb it should be raised and a thin liner placed under the bottom box.

In most modern engines the main bearing is so constructed that by raising the shaft an inch or two the bottom bearing

can be removed for examination or repair. In the center-crank engines the wear of the back quarter-box does not throw the shaft out of alignment with the crank; it decreases the head-end piston clearance. In placing liners behind the back quarter-boxes care must be taken to use the same thickness of liners for each to prevent throwing the shaft out of alignment. Some of the improved engines have a wedge under the bottom of the main bearing which allows the shaft to be raised without the use of liners.

As modern engines are so constructed that the bearings can be flooded with oil, run a stream of it to the crank, crosshead and main bearings, the used oil being drained from the bed, filtered, cooled and used over again. On the eccentric, compression grease cups are used unless the eccentrics are well inclosed, in which case oil can be used without throwing too much on the floor.

Grease is used exclusively on our governor bearings and links and valve-gear, as it is cheaper, cleaner and requires less attention.

Gas Explodes Tar Tank

BY F. S. HADFIELD

A tank used for storing crude tar at the plant of the Globe Soap Co., St. Bernard, Ohio, exploded, July 19, by the ignition of accumulated gas fired by a small flame used to melt out the tar draw-off pipe.

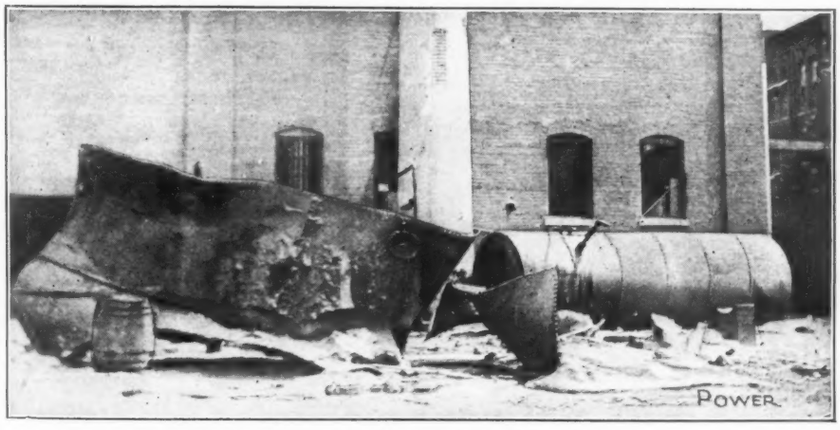


FIG. 1. PART OF THE EXPLODED TANK.

FIG. 2. ANOTHER VIEW OF THE SHELL

The tank was formerly an old return-tubular boiler, the tube sheets of which had been replaced by dished heads. The plates were originally $\frac{7}{16}$ in. thick but had wasted to $\frac{13}{32}$ in. The longitudinal joints were single-riveted, butt-strap, a peculiar joint, and the girth seams single-riveted lap joints.

From the direction of the explosion and the appearance of the plates the tank failed by the rivet holes pulling out in the longitudinal joints, the tank opening up at this point and straightening the sheets out practically flat, tearing themselves loose from the heads, which were blown about 20 ft. The top sheet containing the manhead was blown about 200 ft. and the manhead cover about 600 ft.

Although two men were working at the tank and several were near-by at the time, no one was injured.

Fig. 1 shows the exploded tank and another tank which was beside it. The second tank, full of tar, weighing some 30,000 lb., was lifted off its foundations and moved about 8 ft.

Fig. 2 shows the second tank and the wreck of the foundations, and Fig. 3 the rivet holes pulled out. The seam at the extreme top of the picture was one of the ends of the tank. The view also shows how the tank was unrolled and partially bent in the other direction.

The sheet that failed by pulling out of the holes was originally the fire sheet of the boiler and shows evidences of crystallization. The lap on these seams was 1½ in.

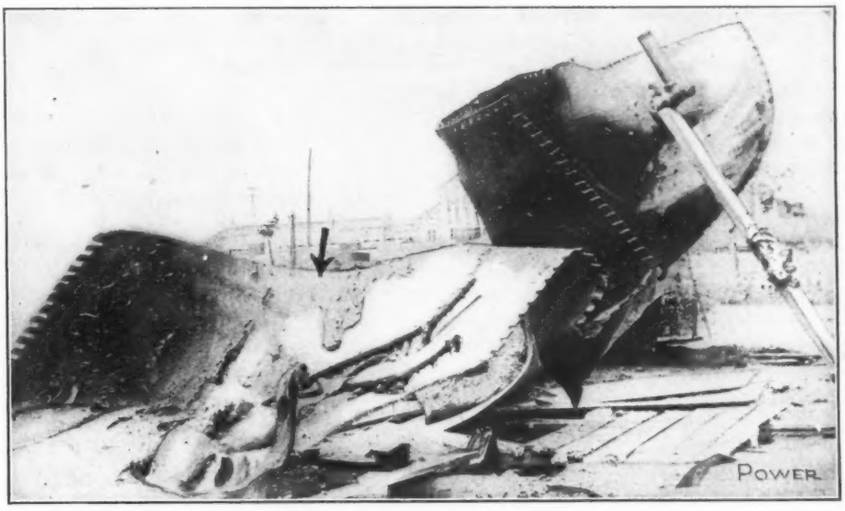


FIG. 3. SHOWING TORN RIVET HOLES

The line of the sheet, indicated by the arrow, shows where the plate was ripped apart for some 10 ft. of its length, the fracture showing a rather crystalline structure.

S. & S. Stationary Tachometer

This stationary tachometer, manufactured by Schuchardt & Schutte, 90 West St., New York City, indicates on a dial the rates of revolutions per minute of the machine being tested.

The result, either revolutions per minute, speed per minute, periods, or miles per hour, is instantly shown without calculation or timing with a watch. Any variations occurring during a fraction of a minute in either right or left-hand revolutions or speeds are indicated, thereby enabling the engineer to control and regulate the speed of the machine.

The instrument is equipped throughout with ball bearings and operates by weights which are acted upon by centrifugal force counteracted by springs. The device is driven by pulley and belt or a spring coupling. The housing is of aluminum alloy.

The "Manual for Engineers," a handy flexible leather-bound pocketbook containing metric-conversion tables, cubes and roots, weights, logarithms, tensile strains, flow of steam, and other engineering data, may be obtained by writing to Greene, Tweed & Co., New York City, and inclosing 10c. in stamps.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Electric Motor Gear Drives

By John S. Leese

Operators frequently complain of the unsatisfactory performance of motors which are gear-connected to the driven shafts. Usually the motor manufacturer is undeservedly blamed for the noise and vibration, whereas the trouble is almost invariably due to the straight-cut gears being operated at excessive pitch-line speeds, setting up noise and vibration, the latter causing bad commutation. Upon looking into the subject carefully, the writer has found that generally the motor manufacturers had strenuously objected to furnishing high-speed motors and large gear reduction, offering instead slow-speed direct-connected machines.

A slow-speed motor for direct connection is slightly more expensive than a high-speed motor of the same output. First cost, however, is not the only consideration, and most experienced owners and engineers will prefer to pay a little more at the outset and avoid continued noise and constantly recurring troubles during operation.

There are five alternatives to straight-cut gearing for transmitting power to the driven element, that is, when the centers are too short for belts or ropes. These are worm gears, helical gears, double helical or herringbone gears, bevel gears and chain drive.

Worm Gears

The perfection of gear-cutting machinery and processes has led to the greatly enhanced efficiency of this means of power transmission and the worm gear is now fully as efficient as the straight-cut gear. Some end thrust occurs along the worm shaft, it is true, but this is provided for by some form of ball or roller thrust-bearing. Worm gears will wear well and be almost as silent after long service as at the beginning. There is nothing about a well cut worm gear to set up chattering or vibration; in fact, the writer has sometimes observed that their application has appeared to have a distinctly steadying effect on both the motor and the driven shafts.

That worm gears are not more widely used for transmitting power from electric motors may be due to their high first cost and suitability only for comparatively large speed reductions. The first objection prevails against the worm in most small motor applications, and the second makes it necessary, as a rule, to employ a very high motor speed and slow speed for the driven element. When this driven part is a line-shaft, either the size of the pulleys on it must be increased or the size of those on the driven machines decreased.

Single Helical Gears

Helical gears are much more expensive than straight-cut gearing, although fairly silent in operation at considerably higher speeds. This is because the teeth come into contact gradually and with less impact than do straight-cut teeth. On the other hand, helical gearing requires heavy thrust bearings, equal thrusts being imposed in opposite directions along both shafts.

Double Helical Gears

Double helical gearing may be used without noise or vibration with high pitch-line velocities and obviates the objectionable feature of thrust which is prevalent with simple helical gearing. Many drives of this class are in use for all sizes and high speeds. The sole objection to this class is that of first cost.

Bevel Gears

This type need not be considered for motor drive except in special cases. As a rule, it is noisier than straight-cut gearing and sets up more vibration, as well as putting end thrusts on both the driving and driven shafts.

Chain Drive

With silent chains applied to industrial drives, the driving and driven shafts must be very carefully aligned and where the power exceeds about 150 hp.,* the width of chain necessary renders such alignment difficult. When the chain exceeds 10 in. wide an outboard bearing for the motor shaft and closely located bearings for the driven shaft are usually required. Again, chains cannot, as a rule, be used for pitch-line speeds exceeding about 1250 ft. per min. with any more chance of success than straight-cut gearing will have at pitch-line speeds above 1000 ft. per min. This is because centrifugal force tends to throw the chain away from the sprockets at the high speeds.

For straight-cut gears a satisfactory way to reduce the pitch-line speed might seem to be to reduce the diameter of the driving pinion. This cannot be carried beyond a certain point for three reasons, namely: 1. The minimum limit to the number of teeth in the wheel must not be passed, and reduction in pitch involves widening the wheel. 2. The diametrical thrust on the shaft is rapidly increased as the diameter of the wheel is reduced. 3. The hole in the wheel boss limits the extent to which metal can be cut away with safety.

From the foregoing, it will be seen that for all ordinary circumstances and low powers, using straight-cut gearing with pitch-line speeds which exceed 1000 ft. per min. is disadvantageous. This does not mean that such speeds cannot be exceeded, for in a number of good drives it is; but in these cases care is taken to keep the gearing quiet, the loads are steady, and the shafts are particularly well supported. All that can be said definitely is that if the user specifies higher pitch-line speeds than 1000 ft. per min. for straight-cut gearing to use a cheap high-speed motor, he must not blame the motor manufacturer if noise and vibration result.

*Chain drives have been used successfully for transmitting considerably over 1000 hp., but different conditions prevailed from those herein discussed. Furthermore, Morse chains are operated at speeds of 2000 ft. per min.—Editor.

Lessons of Some Recent Electrical Fires

By H. S. Knowlton

Recent examination into the causes of a number of fires of electrical origin showed most of them to have been preventable. There are, of course, failures of insulation which cannot be anticipated without prohibitive expenditures for testing, but, on the other hand, a large percentage of the fires and accidents occurring yearly as a result of improper electrical conditions result from those operating plants or engaged in construction in close proximity to electric circuits failing to exercise the proper amount of care.

Loose connections are always fertile causes of trouble, as illustrated in the case of a low-potential arc lamp having a loose binding post. The contact was so poor that the insulation of the wire was ignited, and about 18 in. was burned off, charring the floor timber from which the lamp was suspended and threatening the entire building.

In another instance, a fire loss of over $10,000 resulted from placing an oily piece of canvas over a motor operating in a coal-hoisting tower. Sparks from

the contacts of the controlling switch were communicated to the canvas, and the adjacent woodwork was immediately set afire. The use of an asbestos guard or a rubber blanket covering would have prevented the trouble.

Again, careless handling of tools and metal around wiring often results in serious damages. In one case men working in a cellar of a building partially torn down brought an iron pipe into contact with the live terminals of a service switch, current passing from this pipe to a gas pipe in front of the building, melting a hole in the gas pipe and setting fire to the gas. A loss of $225 resulted from this apparently trifling carelessness in handling the pipe.

Dampness is always a foe to insulation, even on low-potential circuits. A slight fire occurred in one plant, due to the insulation of a wire in molding deteriorating on account of damp conditions. Electrolytic action took place, the wire becoming corroded to a fracture point, and when it broke, an arc established the incipient blaze.

Poor mechanical construction in supporting a steam-heating line led to the pipes falling across the service wires which were burned off, with subsequent melting of a hole in the steam piping and a small fire in clothing hanging near-by. In another case a staging used in the construction of a new building was brought in contact with a series arc-lighting wire; on account of rain the staging and the insulation of the wire were wet, and when the circuit was closed at night, arcing and burning occurred between the wire and the staging.

Combinations of circumstances which result in the starting of many fires are highly suggestive. In one instance a short-circuit occurred in the wires leading to a rheostat which had been temporarily placed above a large belt. The "short" was insufficient to blow the fuses or to open the circuit-breakers, but continued as a small arc with the result that several drops of melted copper fell upon the belt and were carried along with it and thrown among the papers on the chief engineer's desk near-by; the loose papers being set on fire and destroyed.

The wires of a city arc machine and the conduit from the magnetite arc system were so close on the basement ceiling that after whitewashing the ceiling the insulation became wet and allowed the current to jump across to the conduit, starting a fire. The trouble was discovered by flashing on the magnetite loop, which attracted the attention of the operating engineer, and immediately afterward smoke was seen coming from the basement. Sand extinguished the fire.

The floor of a power house was also set on fire by excessive heating of battery wires connected with an engine-stop device, the wires having become crossed with the local 500-volt service. The incident demonstrated the vital importance of separating low-potential circuits from lines carrying dangerous voltages and of avoiding all loose wiring in interior work unless of approved flexible construction.

Sand quickly extinguished another fire which was found under the ratchet of the slide-rail on a three-wire direct-current generator. The rails rested on foundations about 6 in. below the floor level, and the flooring had to be cut out to allow the ratchet to be worked. This open space had become filled with an accumulation of waste ravelings, sweepings, etc., and a spark from the brushes apparently fell into the hole and started a smouldering fire.

In another plant of rather out-of-date design a fire was caused by the commutator on a belted generator flashing over and setting fire to a transmission rope which ran directly above the commutator. The burning rope carried the fire to the oil-soaked floor and to the ceiling of the engine room; the floor and roof timbers being burned and scorched, and one transmission rope so badly scorched that it had to be removed. The entire plant was shut down for two hours. Later a noncombustible shield was placed between the commutator and the rope.

CORRESPONDENCE

Putting Generators on the Line

In the article on "Inspecting and Testing Electrical Apparatus," by A. L. Cook in the Aug. 6 issue under "Putting Generators on the Line," the author says "if a new compound or interpole generator will not take its share of the load, the machines should be tested separately to see that they give the same voltage for corresponding loads, and, if necessary, the shunts on the series coils should be adjusted so they will."

Replying to this, I would say that a shunt across the series field coils of any one machine also shunts the series coils of any other machines in parallel with it, and lowers the compounding, or rise in voltage with the load, of all the machines in parallel. To insure each machine taking its proper share of the load, the drop across the series field coils—in other words, the resistance of the series field coils—must be in proportion to the capacity of the machine as referred to the resistance of the field coils and the capacity of the remaining machines. If two generators of the same capacity or rating differ in the resistance of their series fields, the one having the least resistance will carry more than its share of the total current around its series field, thus building up a higher voltage than its mate and taking more than its share of the load. Adding a shunt across the series field terminals provides another path for the current and will lower the station voltage in proportion to the amount of current passed by the shunt.

The remedy in such a case is to place a resistance in series with the series field of right amount to cause both machines to have the same drop across the series field terminals. If the machines are of different capacity, the drop should be proportional to the capacity.

P. L. WERNER.

McKeesport, Penn.

Mr. Werner's communication with reference to the adjustment of shunts on the series windings of compound machines, discusses a phase of the problem which the author intentionally omitted as it is a matter belonging more properly to the design of the wiring. Mr. Werner's statement that a shunt across the series field of one machine changes the compounding of all, should be qualified somewhat since the effect of the shunt is greatest upon the series field to which it is connected. As the shunts are connected directly at the terminals of the series coils and not at the busbars, there is an appreciable resistance between a shunt on one machine and the series windings of the other machines; this resistance being that of the cables which connect the machines to the busbars.

If two or more compound machines are to be run in parallel, it is essential, in the first place, that they have the same degree of compounding; in other words, that they give the same voltage at corresponding loads. This is secured by running the machines separately and adjusting the series shunts. With machines of similar design and with a proper layout of main cables, the machines should then operate satisfactorily in parallel. Assuming the shunts to be adjusted to give the proper degree of compounding when operated separately, then in order that the machines may run properly in parallel, the resistance of each circuit between the positive and the equalizer busbars through the series winding and shunt, if there is one, must be inversely proportional to the rating of the machines; this is so that each series winding may take its proportion of the total current. In some cases this requires additional resistance inserted in the leads between the machine and the busbars if the difference in the lengths of the leads is considerable for the different machines.

This is generally most easily accomplished by inserting an extra length of cable in the machine with the short leads. A matter like this, however, is supposed to be taken care of in planning the station wiring and would not properly be included in an article on electric testing. The writer considers this method of adjusting compound machines preferable to placing a resistance in series with the series winding of the machine.

A. L. COOK.

Montreal, Can.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Before and After Taking in a Charge

By Cecil P. Poole*

Figures intended to tell what happens to a gas and air mixture inside an engine cylinder are easy to work out; but figures that tell what really does happen never have been worked out accurately, unless by accident.

Changes of temperature within a cylinder must be largely guessed at, the guess modified by an estimate based on meager experience and the net result viewed with suspicion, because no thermometer yet made will record both instantaneously and accurately and also withstand the high temperatures occurring in a gas-engine cylinder.

While getting into the cylinder the gas and air are subjected to two influences which produce uncertain results; throttling, due to friction in passing through the passages leading into the cylinder, and heating, due to contact with the cylinder walls, with the hot spent gases left in the clearance, etc. Both reduce the weight of air and gas actually taken into the cylinder. It is frequently stated that the volume is reduced, but this is not true; the volume, figured back to atmospheric pressure is less than the number of cubic inches of space in the cylinder, but the actual volume is the same as the space in the cylinder. This expansion lowers the pressure so that at the end of the suction stroke it nearly always is slightly below atmospheric pressure.

A "stop" indicator diagram shows very clearly this drop in pressure due to throttling; Fig. 1 is such a diagram and indicates an absolute pressure of 13¼ lb. per sq.in. in the cylinder just before the piston starts on the compression stroke. The pressure first drops sharply as the piston starts on the suction stroke, producing a "bag" in the pressure line between *A* and *B;* then it rises gradually to the end of the stroke.

The fluctuations in pressure during admission are due to a combination of inertia and heating. When suction begins, the inertia of the mixture prevents it from entering instantaneously; therefore the pressure in the cylinder falls sharply, the burned gases in the clearance expanding as the piston moves forward. As soon as the difference between the pressure in the cylinder and that of the atmosphere is enough to overcome the inertia of the mixture, it enters with a rush. As the piston speed increases toward the middle of the stroke, the velocity of the incoming charge increases also, and when the piston has passed mid-stroke and its speed decreases, the inertia of the moving charge tends to keep up the velocity and there is a slight piling up behind the piston which raises the pressure slightly toward the end of the stroke. This is shown by the gradual rise of the suction pressure line from *B* to *C*, and the sharper curve from *C* to *D*, Fig. 1. The heating of the charge also helps raise the pressure; hence it is wrong to suppose that the difference between the pressure at the end of the suction stroke and atmospheric pressure is an accurate measure of the effect of throttling.

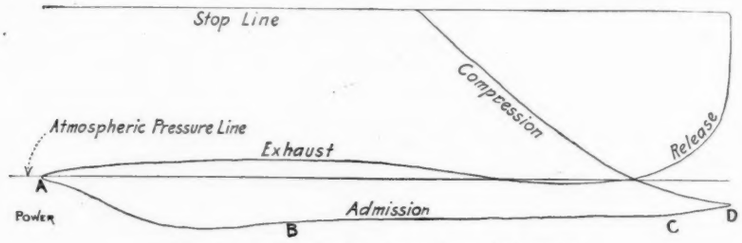


Fig. 1. A Representative Stop Diagram

The weight of mixture taken into the cylinder being less than the weight of the same volume at atmospheric pressure produces two unfavorable effects on the operation of the engine; it reduces the available energy in the mixture and the effective compression ratio. For example, suppose the piston displacement were 100 cu.in. and the clearance volume 25 cu.in.; then the total volume behind the piston before compression begins would be 125 cu.in., and when compression is complete, 25 cu.in., making the mechanical compression ratio

$$125 \div 25 = 5$$

With this ratio, under ordinary working conditions, the compression pressure would be about 8.1 times the pressure in the cylinder just before compression begins. Therefore, if the displacement efficiency were 100 per cent.—that is, if the piston drew in exactly 100 cu.in. of mixture during the suction stroke, making the pressure just before compression begins equal to atmospheric pressure (14.7 lb.)—the final compression pressure would be 119 lb. per sq.in., abs. If the mixture contained 2¼ B.t.u. per cu.in. at atmospheric pressure and temperature, and if its temperature were not changed during admission, the charge taken in would contain 225 B.t.u.

If the displacement efficiency were only 80 per cent., still assuming the temperature of the mixture constant during admission, the piston would draw in only 80 per cent. of the weight of mixture which occupied 100 cu.in. at atmospheric pressure, and the total B.t.u. taken in would be 180 instead of 225. The pressure in the cylinder at the end of the suction stroke (always assuming no change of temperature in the mixture) would be 11.8 lb. per sq.in. abs., instead of atmospheric pressure, and the piston would have to travel through 20 per cent. of its compression stroke before the pressure rose to atmospheric. Therefore, reckoning from the basis of atmospheric pressure, compression would really not begin until 20 per cent. of the compression stroke had been traveled. This condition is illustrated in Fig. 2.

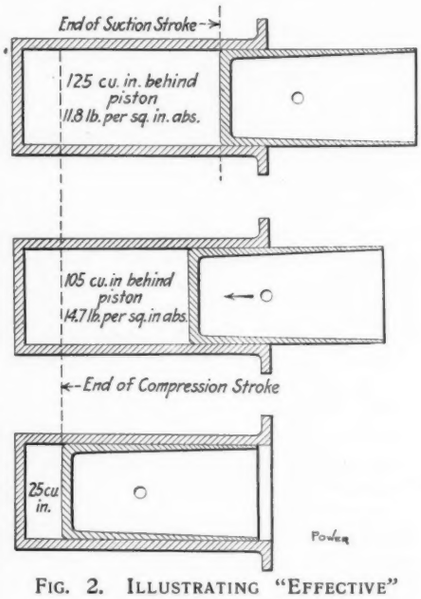

End of Suction Stroke
125 cu. in. behind piston
11.8 lb. per sq. in. abs.
105 cu.in behind piston
14.7 lb. per sq. in abs.
End of Compression Stroke
25cu in.
Power

Fig. 2. Illustrating "Effective" Compression

*Consulting engineer, Atlanta, Ga.

The volume behind the piston just before the pressure began to rise above atmospheric would be 105 cu.in. instead of 125; consequently, the effective compression ratio would be

$$105 \div 25 = 4.2$$

instead of 5. With this ratio, the compression pressure would be about 6½ times the atmospheric pressure instead of 8.1 times, making the compression pressure 95½ lb. per sq.in. abs., instead of the 119 obtained in the first example, in which 100 per cent. displacement efficiency was assumed.

However, if a stop diagram is available, making known the pressure at the end of the suction stroke, the mechanical compression ratio (the volume behind the piston before compression begins divided by that when compression is completed) can be used, and it is sufficient to remember that the scale of pressures is lowered. That is, the pressure just before compression being lower than atmospheric, the pressure at the end of compression will be correspondingly lower than if no pressure had been lost during admission.

For example, starting from the reduced pressure of 11.8 lb. per sq.in. abs., at the end of the suction stroke with 80 per cent. displacement efficiency, and taking the full mechanical compression ratio of 5, the compression pressure would be

$$8.1 \times 11.8 = 95.6$$

practically the same as that computed on the basis of *effective* compression ratio and atmospheric initial presssure.

For simplicity the foregoing illustrations were based on the assumption of a constant temperature of the mixture during admission; but such is never obtained under normal running conditions; the temperature is always increased more or less above atmospheric, and this raises the pressure slightly above what it would be with the same displacement efficiency. The rise in temperature may be as small as 10 per cent., or as great as 25 per cent. of the absolute temperature of the atmosphere, or even more. Although the temperature in the cylinder cannot be measured accurately, approximate measurements have shown the temperature rise during admission ordinarily to be about 15 per cent. of the absolute temperature of the mixture before entering.

It is important to distinguish between the effects of throttling and heating. Both reduce the weight of gas and air taken in, but very differently; throttling does it by opposing the flow mechanically, heating by expanding the mixture. If it were not heated, the weight (and therefore the heat content) of the charge actually taken in would be equal to the weight (and therefore the heat content) of a cylinderful of mixture at atmospheric pressure multiplied by the displacement factor. (Often referred to as displacement efficiency.) But as there is a rise in temperature, some other factor must be used to apply to actual conditions, and this may appropriately be called the "intake factor." This is a number by which the theoretical capacity of the cylinder must be multiplied to get the actual weight or heat content of gas and air taken in per stroke under operating conditions.

For example, suppose the piston displacement were 100 cu.in. and that quantity of mixture contained 200 B.t.u. at atmospheric pressure and temperature. Also suppose that the intake factor of the engine were 77 per cent.; then the piston would draw in 77 per cent. of 200, or 154 B.t.u. at each full suction stroke.

If the rise in temperature during the suction stroke could be ascertained, this, with the pressure in the cylinder just before compression begins, would enable one to determine with sufficient accuracy for all practical purposes, the intake factor or efficiency of the engine; that is, the proportion of the theoretical weight of mixture that the piston actually draws into the cylinder. Suppose, in the example just given, the intake factor had not been known and temperature rise had been 17 per cent. with the pressure at the end of the suction stroke 13 lb. Referring to Table 1, in the column headed 13 and in line with 17 per cent. temperature rise will be found the intake factor, 77 per cent.

TABLE I. SHOWING RELATION BETWEEN FINAL INTAKE PRESSURE, TEMPERATURE RISE AND INTAKE FACTOR

(Figures in Body of Table are Intake Factors, Expressed in Percentage.)

Per cent. absolute temperature rise	Absolute Pressure at End of Suction Stroke														
	12	12¼	12½	12¾	13	13¼	13½	13¾	14	14¼	14½	14.7	15	15¼	15½
10	74.2	75.8	77.3	78.8	80.4	81.9	83.5	85.0	86.6	88.1	89.7	90.9	92.8	94.3	95.9
11	73.5	75.1	76.6	78.1	79.7	81.2	82.7	84.3	85.8	87.3	88.9	90.1	91.9	93.5	95.0
12	72.9	74.4	75.9	77.4	79.0	80.5	82.0	83.5	85.0	86.6	88.1	89.3	91.1	92.6	94.1
13	72.2	73.7	75.2	76.8	78.3	79.8	81.3	82.8	84.3	85.8	87.3	88.5	90.3	91.8	93.3
14	71.6	73.1	74.6	76.1	77.6	79.1	80.6	82.1	83.5	85.0	86.5	87.7	89.5	91.0	92.5
15	71.0	72.5	73.9	75.4	76.9	78.4	79.9	81.3	82.8	84.3	85.8	87.0	88.7	90.2	91.7
16	70.4	71.8	73.3	74.8	76.2	77.7	79.2	80.6	82.1	83.6	85.0	86.2	88.0	89.4	90.9
17	69.8	71.2	72.7	74.1	75.6	77.0	78.5	80.0	81.4	82.9	84.3	85.5	87.2	88.7	90.1
18	69.2	70.6	72.1	73.5	74.9	76.4	77.8	79.3	80.7	82.2	83.6	84.8	86.5	87.9	89.4
19	68.6	70.0	71.5	72.9	74.3	75.7	77.2	78.6	80.0	81.5	82.9	84.0	85.7	87.2	88.6
20	68.0	69.4	70.9	72.3	73.7	75.1	76.5	78.0	79.4	80.8	82.2	83.3	85.0	86.5	87.9
21	67.5	68.9	70.3	71.7	73.1	74.5	75.9	77.3	78.7	80.1	81.5	82.6	84.3	85.7	87.1
22	66.9	68.3	69.7	71.1	72.5	73.9	75.3	76.7	78.1	79.5	80.9	82.0	83.6	85.0	86.4
23	66.4	67.8	69.1	70.5	71.9	73.3	74.7	76.1	77.4	78.8	80.2	81.3	83.0	84.3	85.7
24	65.8	67.2	68.6	69.9	71.3	72.7	74.1	75.4	76.8	78.2	79.5	80.7	82.3	83.7	85.0
25	65.3	66.7	68.0	69.4	70.7	72.1	73.5	74.8	76.2	77.5	78.9	80.0	81.6	83.0	84.4

The displacement factor of an engine can be determined practically by driving it from an external source at its rated speed, having it take in air from a small holder and measuring the air by the holder drop; this is simple and easy, but expensive with a large engine, unless a holder happens to be at hand and the plant idle. But the displacement factor does not cover the rise in temperature during the entrance of the mixture into the cylinder, and there is no direct relation between it and the intake factor, which does.

The intake factor can be determined experimentally by operating an engine at full load and supplying it with gas and air taken from calibrated holders or delivered through meters for a certain length of time during which the number of strokes made by the piston are counted. Multiplying the piston displacement in cubic feet per stroke by the number of strokes made during the observation period and dividing this product into the total number of cubic feet of mixture taken in during that period will give the intake factor. For example, suppose an engine with a cylinder 10x16½ in. were running at full load and making 200 r.p.m. The piston displacement per stroke would be ¾ cu.ft. (approximately) and, assuming that the engine worked on the four-stroke cycle, it would make 100 suction strokes per minute, or 6000 per hour; the piston displacement per stroke multiplied by the number of suction strokes per hour would be 4500. Now suppose that the gas and air meters or holders showed that a total of 3300 cu.ft. of gas and air was delivered to the engine in one hour. Then the intake factor would be

$$3300 \div 4500 = 0.7333$$

or 73.33 per cent.

In considering the behavior of gases, absolute temperatures must be used. (The absolute temperature of a gas is 460 deg. greater than the Fahrenheit thermometer temperature, because absolute zero is 460 deg. below the Fahrenheit zero.) Therefore, in speaking of the percentage of temperature rise during admission, the percentage of the *absolute* temperature of the atmosphere is meant. For example, if the atmosphere is at 80 deg. F., or 80 + 460 = 540 deg. absolute, and the temperature of the mixture increases 17 per cent. during admission (17 per cent. of 540 = 91.8 deg.) the absolute temperature at the end of the suction stroke will be 540 + 91.8 = 631.8 deg. or practically 632, and the thermometer temperature will be 631.8 — 460 = 171.8 deg. Table 2 gives the Fahrenheit tem-

peratures in the cylinder corresponding to different percentages of absolute temperature rise. The numbers in the left-hand column are Fahrenheit thermometer temperatures of the mixture before entering.

One further example should suffice to make clear the application of the tables. Let the temperature of the atmosphere be 70 deg. (the atmospheric pressure being 14.7 lb. abs.), the pressure in the cylinder at the end of the suction stroke 13½ lb., and the intake factor of the engine as found by experiment, 80 per cent. What is the temperature in the cylinder at the end of the suction stroke?

Referring to Table 1, follow down the 13½-lb. column to the number 80, which is the intake factor; then following across to the left-hand column, 17 will be found as the percentage of absolute temperature rise. Now locate in the left-hand column of Table 2 the atmospheric temperature (70 deg.) and trace across until the 17 per cent. column is reached; in this column is the number 160, which is the thermometer temperature of the mixture in the cylinder.

Referring to Table 1 again, it will be noted that the range of absolute pressures at the end of the suction stroke is carried above atmospheric pressure. This is for the purpose of making the table apply to those infrequent cases in which the temperature rise is so great that the final suction pressure in the cylinder is above atmospheric pressure.

These two tables will be found interesting, if not of highly practical value, in showing the relation between the pressure drop and temperature rise during admission, and the intake factor of an engine. The relation is not rigidly accurate as computed, because the figures are based on the law of perfect gases (of which there are none), but they are more nearly accurate than the average observations with an indicator and a pyrometer.

TABLE 2. THERMOMETER TEMPERATURES IN CYLINDER CORRESPONDING TO DIFFERENT OUTSIDE TEMPERATURES AND ABSOLUTE TEMPERATURE INCREASES DURING ADMISSION

(Numbers in Body of Table are Thermometer Temperatures in Cylinder at End of Suction Stroke)

Air Temp. at Intake Deg. F.	Percentage of Absolute Temperature Rise During Admission to the Cylinder															
	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%	25%
40	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165
41	91	96	101	106	111	116	121	126	131	136	141	146	151	156	161	166
42	92	97	102	107	112	117	122	127	132	137	142	147	152	157	162	168
43	93	98	103	108	113	118	123	128	134	139	144	149	154	159	164	169
44	94	99	104	110	115	120	125	130	135	140	145	150	155	160	165	170
45	95	101	106	111	116	121	126	131	136	141	146	151	156	161	166	171
46	97	102	107	112	117	122	127	132	137	142	147	152	157	162	167	173
47	98	103	108	113	118	123	128	133	138	143	148	153	159	164	169	174
48	99	104	109	114	119	124	129	134	139	145	150	155	160	165	170	175
49	100	105	110	115	120	125	130	136	141	146	151	156	161	166	171	176
50	101	106	111	116	121	127	132	137	142	147	152	157	162	167	172	178
51	102	107	112	117	123	128	133	138	143	148	153	158	163	169	174	179
52	103	108	113	119	124	129	134	139	144	149	154	160	165	170	175	180
53	104	109	115	120	125	130	135	140	145	150	156	161	166	171	176	181
54	105	111	116	121	126	131	136	141	147	152	157	162	167	172	177	183
55	107	112	117	122	127	132	137	143	148	152	158	163	168	173	179	184
56	108	113	118	123	128	133	139	144	149	154	159	164	170	175	180	185
57	109	114	119	124	129	135	140	145	150	155	160	166	171	176	181	186
58	110	115	120	125	131	136	141	146	151	156	162	167	172	177	182	188
59	111	116	121	126	132	137	142	147	152	158	163	168	173	178	183	189
60	112	117	122	128	133	138	143	148	154	159	164	169	174	180	185	190
62	114	119	125	130	135	140	146	151	156	161	166	172	177	182	187	193
64	116	122	127	132	137	143	148	153	158	164	169	174	179	185	190	195
66	119	124	129	134	140	145	150	155	161	166	171	176	182	187	192	198
68	121	126	131	137	142	147	153	158	163	168	174	179	184	189	195	200
70	123	128	134	139	144	150	155	160	165	171	176	181	187	192	197	203
72	125	131	136	141	146	152	157	162	168	173	178	184	189	194	200	205
74	127	133	138	143	149	154	159	165	170	175	181	186	191	197	202	208
76	130	135	140	146	151	156	162	167	172	178	183	189	194	199	205	210
78	132	137	143	148	153	159	164	169	175	180	186	191	196	202	207	213
80	134	139	145	150	156	161	166	172	177	183	188	193	199	204	210	215
82	136	142	147	152	158	163	169	174	180	185	190	196	201	207	212	218
84	138	144	149	155	160	166	171	176	182	187	193	198	204	209	215	220
86	141	146	152	157	162	168	173	179	184	190	195	201	206	211	217	223
88	143	148	154	159	165	170	176	181	187	192	198	203	209	214	220	225
90	145	151	156	162	167	173	178	184	189	195	200	206	211	217	222	228
92	147	153	158	164	169	175	180	186	191	197	202	208	213	219	225	230
94	149	155	161	166	172	177	183	188	194	199	205	210	216	221	227	233
96	152	157	163	168	174	179	185	191	196	202	207	213	218	224	229	235
98	154	159	165	171	176	182	187	193	198	204	210	215	221	226	232	238
100	156	162	167	183	187	184	190	195	201	206	212	218	223	229	234	240
102½	159	164	170	176	181	187	193	198	104	209	215	221	226	232	238	243
105	162	167	173	178	184	190	195	201	207	212	218	224	229	235	241	246
107½	164	170	176	181	187	193	198	204	210	215	221	227	232	238	244	249
110	167	173	178	184	190	196	201	207	213	218	224	230	235	241	247	253

Minor Defects in Suction Gas Power Plants

By James A. Seager

It is not proposed here to discuss either the gas producer or the engine, but to consider some of the accessories and their minor troubles. For instance, in the wet form of scrubber it is most important that attention be paid to the joints on the clean-out doors. In one instance, leakage occurred past the flanges on the bottom door and resulted in corrosion of the metal. As the water was charged with impurities this corrosion proceeded so rapidly that it was decided to paint the exposed surfaces with anti-corrosive paint. It was thought that this would settle the difficulty, but after 12 mo. it was found that the corrosion had extended to such an extent that it became necessary to thoroughly scrape the metal and cover it with a thin layer of cement.

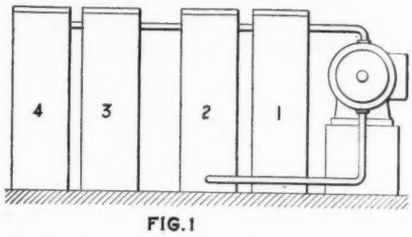


FIG. 1

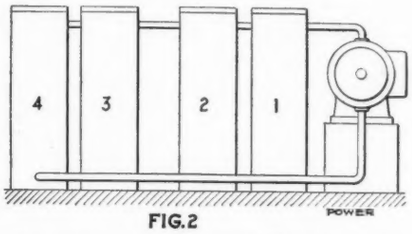


FIG. 2

Incorrect and Correct Connections

Among other minor troubles may be mentioned those occurring in the piping. In one case the exhaust pipe became cracked, due to the hot gases causing an old defect to open. An attempt was made to keep the gases from escaping into the room by putting clamps around the pipe, but this proved ineffective. Therefore, to cure the trouble, a sheet of asbestos packing was softened in water and after becoming flexible it was tightly clamped over the crack.

Many pipe-work troubles occur in connection with the engine cooling-water system; for instance, in a certain suction-gas installation the circulating water was at first cooled by the aid of two cylindrical tanks in series. When the engine was fully loaded, however, these proved inadequate and two similar tanks were added, and connected as in Fig. 1. Tanks 1 and 2 formed the original installation and formed a complete circulating unit, but in connecting tanks 3 and 4 no provision was made for returning the water to the engine; hence the original circulation remained unchanged. The defect was finally corrected by connecting the tanks as in Fig. 2.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Influence of Suction Pressure on Ammonia Compressors*

By Robert H. Karl†

An ammonia compressor is constructed to take in ammonia gas at a low pressure and temperature and discharge it at a higher pressure and temperature. The size and speed of the compressor, or strictly speaking, its piston displacement, is the measure of the capacity of refrigeration.

To say that a machine has a capacity of so many tons of refrigeration means that a certain quantity of liquid ammonia circulated by it will, by evaporating, extract as many heat units from the brine tank as will melt so many tons of ice at 32 deg. F. into water at 32 deg. F. This capacity measurement is not constant and varies considerably under different conditions of operation. A 50-ton machine may produce only 30 tons of refrigeration under certain conditions, while under more favorable conditions it may produce 70.

If a compressor discharges the greatest volume of ammonia gas for a given expenditure of work, that is all the machine can do. The work expended depends on the pressure of the gas entering the compressor, and the pressure against which the gas must be discharged.

A pound of ammonia can either absorb or give off a certain amount of heat by changing from a liquid to a gas or from a gas to a liquid. This transition can occur through a great range of pressure, and since a cubic foot of ammonia gas increases in weight when its pressure increases, and therefore a greater weight of gas can be handled by the same refrigerating machine at higher suction pressure, it is evident that more refrigeration can be performed. Since the amount of work that must be expended increases with the pressure against which the gas must be discharged, the lower this pressure, the less work is required. In other words, the smaller the difference between the condenser and suction pressures the greater the capacity and economy. The suction pressure is governed by the temperature and pipe surface of the refrigerator, and the condenser pressure by the cooling surface and the temperature and quantity of the cooling water. These conditions should be given proper consideration when the plant is installed, and because this is seldom the case many refrigerating plants suffer in capacity and economy. Sometimes for the sake of a few dollars worth of piping, the entire plant is crippled, while on the other hand the compressor may be bought entirely too large or too small.

It may be interesting to see how the pressure of the gas as it passes from the cooling coils to the compressor cylinder, exerts such a marked influence upon the capacity and also upon the economy of the refrigerating machine. The formula for capacity is:

$$F = 0.00505\ N\ M\ [R - (T - t)]$$

where

F = Ice melting capacity in tons per 24 hr.;
N = Strokes per minute;
M = Weight of ammonia per stroke;
R = Latent heat at refrigerator pressure;
T = Temperature in condenser;
t = Temperature in freezing coils;
0.00505 = Reciprocal of B.t.u. per minute per ton of refrigeration.

Since the number of strokes remains constant, it is evident that the capacity depends upon the weight of ammonia, latent heat at the refrigerator pressure and the temperatures in the condenser and the freezing coils.

A table of properties of ammonia, will show that as the suction pressure increases, the corresponding latent heat becomes less, and the corresponding temperature or heat of the liquid rises; consequently the sum of the latent heat and the heat of the liquid in the condenser and freezing coils changes but little with different suction pressures, so that the capacity is practically proportional to the weight of ammonia circulated. For instance, at a suction pressure of 18.45 lb. abs., a cubic foot of gas weighs 0.0689 lb., while at 38.55 lb. abs. pressure it weighs 0.1384 lb., or twice as much.

As the same volume of ammonia gas passes through the compressor in a given time, whatever the pressure, then with the greater suction pressure the machine will circulate double the amount of ammonia and the capacity will be nearly double that at the lower pressure.

It requires more power to operate the compressor at a higher suction pressure, but the power does not increase as rapidly as the capacity. The power is proportional to the heat delivered to the condenser minus the heat taken from the cold body, and the capacity is proportional to the heat taken from the cold body.

The examples following may serve to make things a little clearer. For simplicity, take a saturated gas compressor, 12x24-in. and 70 r.p.m., that works without superheating, the suction pressure to be 10.31 lb. gage and the condenser pressure 200 lb. gage. Each cubic foot of ammonia at the suction pressure would weigh 0.0921 lb., and each stroke of the piston would displace 1.57 cu.ft. of gas weighing 0.1446 lb. Then assuming an efficiency of 80 per cent.

$$F = 0.00505 \times 140 \times 0.1446\ (560.39 - 108) \times 0.80 = 37\ tons$$

requiring about 76.2 hp. The machine would thus fall short about 13 tons of the supposed capacity. If the same compressor were operated at the same speed with a suction pressure of 27.28 lb. gage and a condenser pressure of 170 lb. gage the weight of ammonia discharged per stroke would be 0.2366 lb., and the capacity

$$F = 0.00505 \times 140 \times 0.2366\ (546.88 - 77) \times 0.80 = 62.88\ tons$$

requiring 83.2 hp.

The previous examples show the foolishness of buying a machine of 50 tons capacity without knowing under what conditions it will have to work, for this compressor will develop its rated capacity only with a suction pressure of 18.68 lb., and a condenser pressure of 180 lb. at the same speed and same efficiency. Thus

$$F = 0.00505 \times 140 \times 0.1903\ (553.04 - 90) \times 0.80 = 49.84\ tons$$

and the horsepower would be about 80.4.

The same compressor may, however, produce a great deal more. In the case of wort cooling in a brewery where the suction pressure is 44.72 lb. and the condenser pressure 180.43 lb. the weight of ammonia discharged per stroke is 0.3295 lb. and the capacity becomes

$$F = 0.00505 \times 140 \times 0.3295\ (536.91 - 64) \times 0.80 = 88.13\ tons$$

requiring 91.2 hp.

It is evident then that the suction pressure greatly affects the capacity even when the machine is running at the same speed. Take the case where the compressor is doing 50 tons of refrigeration with about 1.6 hp. per ton, and compare it with the first case where the same machine working at the same speed at a lower pressure requires 2 hp. per ton.

*Abstract of paper read before the Institute of Operating Engineers, New York City, Sept. 6 and 7.

†Chief erecting engineer, Anheuser-Busch Brewing Co., St. Louis, Mo.

The capacity is reduced 26 per cent. and the horsepower per ton increased 25 per cent.

Now compare the third with the second case, where the suction pressure is increased from 18.68 lb. to 27.28 lb. The capacity of the compressor is increased to 62.88 tons, an increase of practically 13 tons, or 26 per cent. The horsepower per ton has been decreased from 1.6 to 1.32, or 17.5 per cent.

By raising the suction pressure of 10.31 lb. in the first case to 27.18 lb. in the second, the capacity of the compressor was increased 70 per cent. at an expenditure of only 9 per cent. more power. In other words, the extra 25.8 tons of refrigeration required only 7 hp.

Setting the Expansion Valve

BY C. E. ANDERSON

Among engineers operating refrigerating plants, opinions seem to differ concerning the proper setting of the expansion valve. Some claim it best to open wide the expansion valve for 10 or 15 min., depending on the size of the coils, flood the coils with liquid and then close the expansion valve and shut down the pump until the temperature of the ammonia gas returning to the machine is 10 or 15 deg. below the temperature of the cooler or brine tank, when the operation is repeated.

Others contend that the coils should be pumped down to a vacuum before the flooding begins. This works fairly well with rooms that are hard to cool, if it is used once or twice in 24 hr. and the expansion valve is adjusted for continuous feeding. With top expansion on the coils it is not satisfactory. Best results are obtained when the coils are fitted for bottom expansion.

Still others claim that no liquid should pass the expansion valve and be allowed to enter the evaporating coils. Where only gas is being admitted to the coils the latent heat of the liquid ammonia is entirely expended at the expansion valve and the coils do no work. As refrigeration is brought about only at the point of expansion, obviously the liquid must be admitted to the coils.

The first cooling done by the liquid ammonia is upon itself until it reaches the cooler temperature; hence the lower the cooler temperature the less useful refrigeration will be produced per pound of liquid ammonia. In every transfer of heat certain losses are unavoidable; first, because a temperature difference is necessary to cause a heat transfer, and it takes energy to maintain a temperature difference; second, to effect a heat transfer, requires certain apparatus, and with this heat is lost by absorption.

Assume the condensing water at 60 deg. F. and the condenser pressure 126.5 lb. gage, which gives the condensed ammonia gas, or the liquid, a temperature of 75 deg. F. The specific heat of liquid ammonia is variously given from 1 to 1.22. Take a mean value, 1.1. To reduce 1 lb. of ammonia liquid from 75 deg. to zero requires removing

$$75 \times 1.1 \times 1 = 82.5 \text{ } B.t.u.$$

This only reduces the liquid ammonia temperature and not the room or brine temperatures. In practice this is done by opening the expansion valve and allowing the liquid ammonia to pass from a higher to a lower pressure, or, in this case, from 126.5 to 15 lb. gage, or from 75 to 0 deg. F. On reaching the lower pressure, the liquid will give up 82.5 B.t.u., and 82.5/556 of the pound of liquid ammonia will vaporize. The pound of ammonia is now in the cooling coils, 82.5/556 of it vapor and 473.5/556 lb. still liquid.

Suppose the evaporating coils are in a cold-storage room whose temperature is 10 deg., the ammonia temperature being zero. Every heat unit the evaporating coils absorb from the room will evaporate a definite amount of the liquid. When 473.5 B.t.u. has been absorbed, all of the liquid ammonia will be evaporated, because

$$473.5 + 82.5 = 556 \text{ } B.t.u.$$

which is the latent heat of liquid ammonia at 15 lb. pressure or 0 deg. F.

Evidently, therefore, the liquid must pass through the expansion valve to the coils to derive the benefit of the latent heat, or one of the very important properties for which ammonia was chosen as a refrigerating agent will be lost.

CORRESPONDENCE

Data on Absorption System

Some data on absorption machines by Fred Ophuls, published in the issue of Apr. 23, has just come to the writer's attention. From a scientific standpoint the data is interesting and particularly that on moisture in rectifier vapors, but without a little study some of the conclusions drawn may be misleading.

Steam Consumption—A standard absorption machine has a steam consumption of from 30 to 40 lb. per hr. per ton, depending upon conditions, making a total variation of 30 per cent., but Table 10 shows a variation from 32 to 58 lb., or 90 per cent.; hence the tests are not representative.

Rectifier Heat—In test No. 1, Table 9, the figures show a tremendous heat elimination in the rectifier, namely, 43,882 B.t.u., and only 47,603 for the absorber. This discrepancy accounts for the excess steam consumption. The following are some figures of test made by Prof. J. E. Denton on a well known absorption machine on July 1 and 2, 1897; duration 24½ hr:

Water inlet, 68.6 deg.; brine outlet, deg.	13.5
Steam consumption per hour per ton, lb.	32.76
Heat eliminated in rectifier, B.t.u.	290,264
Heat eliminated in absorber, B.t.u.	1,063,876
Per cent. rectifier of absorber heat	27

Test No. 4 more nearly approaches good practice. The rectifier heat is 30 per cent. of the absorber and the steam consumption is 32 lb. per hr. per ton, which is still high, considering the very favorable conditions.

Water Consumption—The illustration indicates that water flows separately over the condenser, absorber and rectifier. Under these conditions the consumption would be excessive. Condenser water should be used over the absorber and then the rectifier, so that the same water would do for all purposes. An absorption machine will use excessive water under the former conditions just as a compound engine will use extra steam if live steam enters each cylinder instead of running from one cylinder to the other.

It is practicable to run absorption machines with 1½ to 2 gal. of water per min. per ton. A compressor should have at least 2 gal. and 3 gal. is better. The tests described by Mr. Ophuls show water consumptions over double what is necessary in good practice.

Standard Practice—Results of tests on regular absorption exhaust-steam machines are produced in the following figures, which show what is to be expected from machines of this type under various conditions and quantities of water:

STANDARD PRACTICE FOR ABSORPTION MACHINES

Steam Press. Lb.	Water Temp. Deg.F.	Outlet Brine Deg.F.	Gal. water per min. per ton	Steam required per hour per ton
3	60	8	2.2	29.9
3	60	0	2.4	32.4
3	65	8	2.4	29.9
15	60	—15	2.7	36.5
30	70	—15	3.2	40.2

(Ammonia pumps exhaust included)

HENRY TORRANCE, JR.

New York City.

A steam-heated pond is obtained by a lumber company owning a mill pond near the Oregon-California line. This was done that no interruption might be met in the work of the employees at that place. During the winter pipes injected steam into the pond. No ice is allowed to form, no matter how low the temperature may fall. In this way about 200 men are kept steadily at work in the logging camps, on the railroad from the timber, and in the sawmill. During the day the engines exhaust steam into the mill pond, and at night dry steam is forced into the water.—*Ambition.*

The Italian government has ordered from Burmeister & Wain, of Copenhagen, four boats for its navy, to be fitted with oil engines.

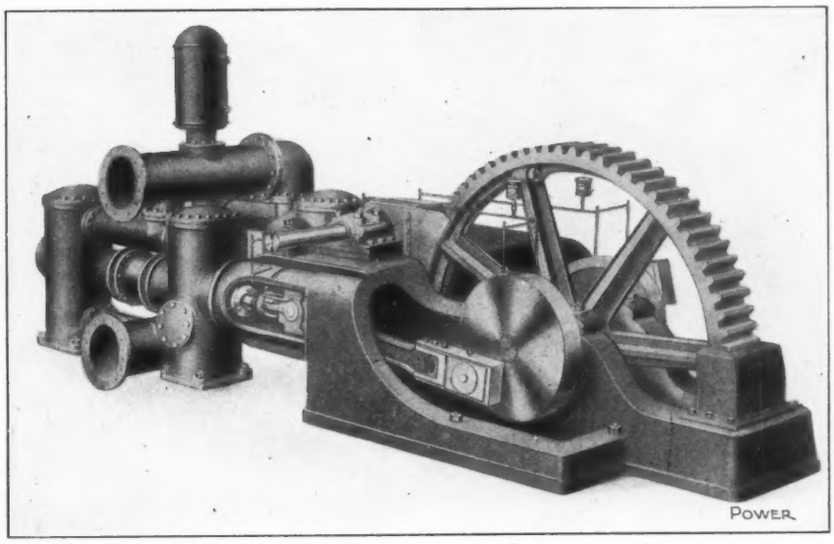
Large Capacity Duplex Pump

A new type of horizontal duplex double-acting power pump for large capacity service in water-works and isolated plants is being placed on the market by the Goulds Manufacturing Co., Seneca Falls, N. Y.

The pinion shaft is extended for direct connection to an electric motor, steam or internal-combustion engine, or other driver.

The power end has a single split cast-iron gear and forged-steel pinion. The teeth in both are machine cut from the solid metal. Three heavy cast-iron girder sections, each carrying a main bearing and crosshead, are doweled and bolted together to form the frame. The crossheads are cast iron with babbitted shoes which have wedge and screw adjustment. The guides are bored.

The water end consists of four castings, each containing a plunger, a discharge and a suction chamber. These castings are held together by large flanged suction and discharge connections, and are bolted to the main frame through the front cylinder.



GOULDS LARGE CAPACITY DUPLEX PUMP

Imperial Mechanical Lubricators

The imperial mechanical lubricators herewith illustrated are manufactured by the Imperial Brass Manufacturing Co., Harrison St. and Center Ave., Chicago. Model A, Fig. 1, is designed for pressures up to several thousand pounds, for all speeds up to 2000 r.p.m. and can be supplied with any number of individual feeds desired. Model B, Fig. 2, has a glass body and is made in 1-pt. size for small units.

Fig. 3 shows the construction of model A. The pump is operated by the ratchet *C*, which turns the cam *D* to which the crosshead *L* is connected. The amount of oil fed depends upon the length of the stroke of the pump plunger *J* which is adjusted by the nuts *M*. On the upstroke of plunger *J* a definite amount of oil is drawn from the suction passage *I* into the pump. This causes a partial vacuum in the oil well *N* and consequently an amount of oil equal to that drawn out by the pump flows from the reservoir into the oil well *N* through the supply tube *G*. On the down stroke of plunger *J* the oil passes through the discharge valve *K* and is forced from the lubricator through the oil pipe and through the pressure valve *F* to the point of lubrication.

This arrangement avoids having the sight-feed glass under pressure. All wearing parts are inclosed and work in a bath of oil. The delivery of oil being accomplished by a single-plunger pump the lubricator is simple and has a small number of parts. Another feature is the use of ball-and-socket joints *Y* on the transmission rod *X*, fitted with springs to take up wear. With this construction perfect alignment is not necessary.

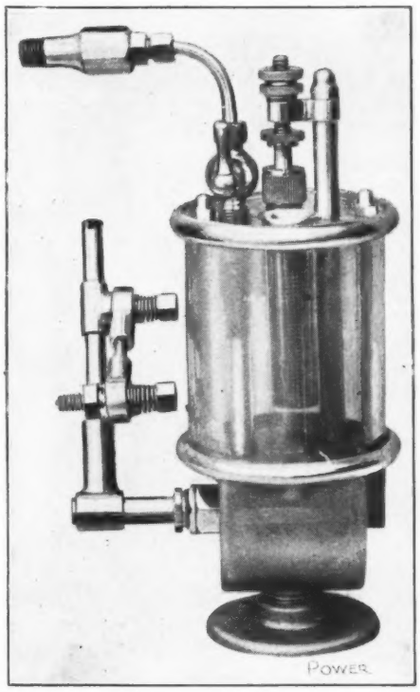


FIG. 2. IMPERIAL MECHANICAL LUBRICATOR. MODEL B

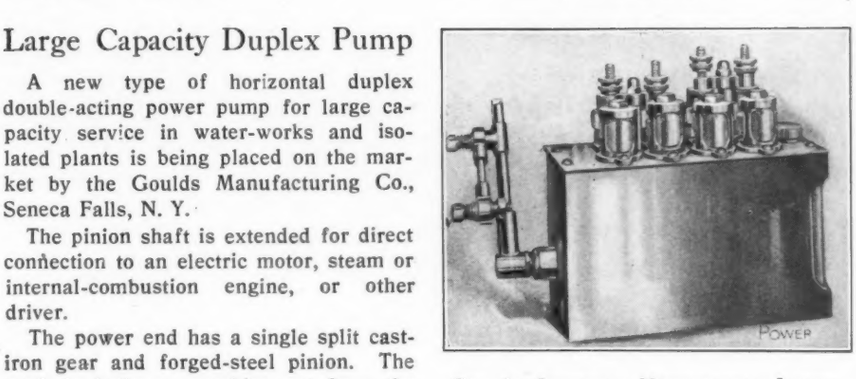


FIG. 1. IMPERIAL MECHANICAL LUBRICATOR, MODEL A

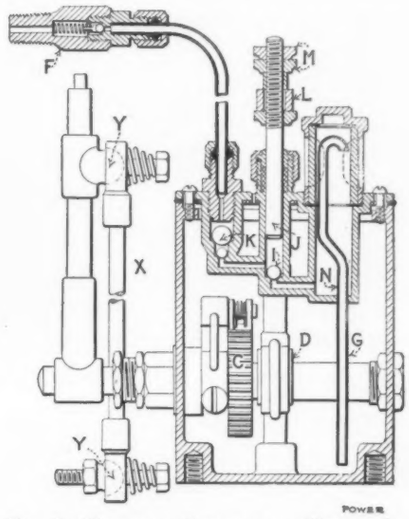


FIG. 3. VERTICAL SECTION OF MODEL A LUBRICATOR

Rucker Tube Blower

A tube blower, for use on return-tubular boilers, in which the steam is given its spiral motion through the tubes has been placed upon the market by the Rucker Manufacturing Co., 15 South First St., Minneapolis, Minn. Three jets of steam are blown through the tube, one from a central outlet in the head of the blower, and passes through the tube in a straight line. The other two jets are given a spiral motion, due to the form of the two tubes attached to the inner head and connecting with its steam supply. The blower is made in sizes from 1½ in. up to 4½ in.

Water Turbines for Panama Power House

By Fred H. Colvin

The illustrations show one of the turbines for the new power house at Gatun which will supply electric power for the locomotives used in handling vessels through the locks at both ends of the canal and also all other power required in the canal zone. There are three of these machines being installed at present, each turbine giving 3600 hp. at a 75-ft. head and a speed of 250 r.p.m. There are also provisions for doubling this installation so that a total of 21,600 hp. can be had if necessary.

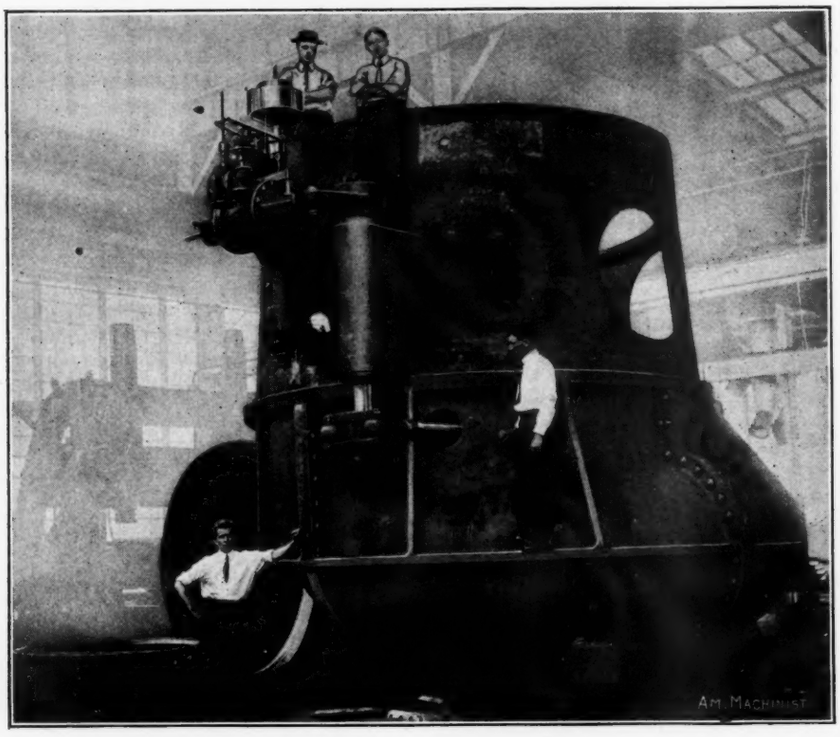


Fig. 1. Setting Up First Unit

Fig. 2. Looking Down at the Wicket Governing Gates

The outside diameter of the casing is about 35 ft. and weighs between 30 and 32 tons. The total height is 21 ft. above the floor when in position in the power house, and the outlet at the bottom will be 3 ft. below this. The generator, made by the General Electric Co., is mounted at the top of the turbine and is 12½ ft. in diameter.

The first unit set up is shown in Fig. 1, which gives some idea of the size of the openings. The inlet is 80 in., being supplied by a pipe line 10 ft. 6 in. in diameter, and the outlet is 76 in. The speed of the turbine will be controlled by 24 wicket gates, whose controlling arms can be seen in Fig. 2.

Each of these wicket gates is 23 in. long, all being controlled from the governor by these arms, which move the outer rings to which the wicket cranks are connected, and in this way increase or decrease the flow of water to the bronze runner. This runner is of government bronze and weighs 7500 lb.

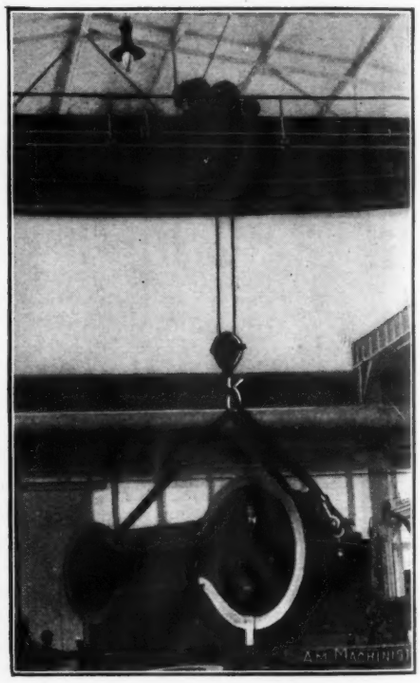


Fig. 3. Showing Size of Casing

Part of the annular casing is shown in Fig. 3, where the piece is swung from the 15-ton crane and a good-sized man is standing in the bore.

The turbines are the design of the Pelton Water Wheel Co., and were built by the Harrisburg Manufacturing & Boiler Co., Harrisburg, Penn.

Not only did James J. Farrell, the engineer who saved the lives of six men by sticking to his post while a heavy electric current passed through his body, display admirable courage, but his presence of mind is equally worthy of note. His devotion and fortitude were typical of the untold instances of intelligent self-sacrifice that enter into the daily life of men who make no pretense to being cast in a heroic mould.—*New York Sun.*

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POWER

Treatment of Boilers

Boiler abuse in small steam plants is more prevalent than in large ones, for several reasons. In large plants the men in charge are, on the average, of a higher grade, have a better understanding of the effects of dirt in boilers, deteriorating effect of expansion and contraction, caused by changes in furnace temperatures and know what to do and what not to do. The methods employed in caring for boilers by the men in the two classes of steam plants vary as conditions dictate.

Often, men in small steam plants are forced to do things they know are detrimental to the life of the boiler, but their better judgment counts for naught, repairs must be made and the boiler must be put into service again, when there is not time to properly do the work.

In one instance, one of two boilers demanded partial retubing. The boiler was in service from 4 p.m. until 7:30 a.m. daily. During the intervening period it was cooled, emptied, one or two tubes removed and replaced by new ones, refilled and steam raised to the working pressure. As the tubes were badly scaled it was slow work removing them, and the eight hours in which the boiler was out of commission was not enough in which to do the work.

As it was the boiler was emptied under pressure, giving it no chance to cool, and was filled with cold water so late that proper time could not be given for slowly heating the water and generating steam. Frequently steam was raised to the working pressure from a cold boiler in less than 90 minutes.

Poor practice certainly, and the work was done against the engineer's better judgment. It was a case of obeying orders or of cutting out one-half of the lighting load when it was most needed. This much is evident, the boiler was injured by the abuse and its life materially shortened.

As a contrast, it is the practice in some power plants to cut out a boiler by closing the valve in the connection between it and the steam main and allow the brickwork and boiler to cool naturally, by letting the fire gradually die out with all draft doors and damper closed. When the boiler is to be put into service again, the fires are started and made to burn slowly for several hours before steam is raised.

Quite a difference in the two methods employed, and after a service of a few years the boilers would speak for themselves, one condemning, the other commending the treatment received.

Friendliness and Familiarity

We give space to the communication under this title on page 466 not because we sympathize with the sentiments it expresses, but because we do not wish to be accused of refusing a critic the chance to present his views.

In a certain manufacturing establishment the memory persists of a highly polished self-important individual thoroughly imbued with the ideas of rank, caste and discipline, which he had contracted at Annapolis, who became its chief executive. One day, as he was showing a party of visitors over his little realm the superintendent of one of the departments spoke to him pleasantly about some matter of shop interest. The calling down which that superintendent got is still one of the shop traditions. In ringing tones he was reminded that he was a subordinate, an inferior, and that never again was he to approach and address his supreme officer in so informal a manner.

This man was universally regarded as a prig and a snob, and outside of a few bread-and-butter flunkies who took his part and spoke him fair, but who would have kicked him over without compunction if his fall would have served their interests, there was not a man in the shop who would not have thoroughly enjoyed any mishap which would put a crimp in his stiff spine or have belittled and embarrassed him.

A short time ago the writer hereof was conducted through another shop by one of its executive officers. No sly warnings, no simulated activity preceded him, no surly glances, supercilious remarks nor mocking grimaces followed in his wake. He gave a cheery word wherever he stopped. He knew most of his men by name, asked after their babies, how the new house was coming along, told another to call at his home and see what "mother" had for his sick wife, knew how long they had been there, and their fathers before them, knew the ambitions and the capabilities of each. He could pick the best man for a given job and the man would sit up nights planning how he could make good to "Uncle Charlie."

Do you think one of them would have slapped him on the back, or asked him to have a drink? Whose dignity was the more secure, that of the prim and pompous ex-naval executive or that of Uncle Charlie, whose men bring their babies around on Sunday to see him and are proud and happy in his notice of them, as he is simple and hearty and natural in his interest in and enjoyment of them?

In which shop is there likely to be the better *esprit de corps*? Which shop is likely to turn out the best work at the least cost? In which shop is working most likely to be like living, with a pleasant, wholesome, craftsman-like interest in what is being created by and about one?

It is unfortunately true that there are individuals who, as our correspondent says, "are inclined to take advantage always of each and every point." Give them an inch and they will take an ell. Speak to them pleasantly today, they will be calling you "old chap" tomorrow, and boasting of their familiarity with you. Of such are the Goops, and they should be sternly repressed to their own level, which is the same whether they work in the fireroom, at a lathe, or over a mahogany desk.

And in closing may we remark that if you will watch the man who is so grandiose and overbearing toward his inferiors, you will probably see an exhibition of the most abject toadyism whenever he is in the presence of anybody who is higher than he in authority or social standing.

When Condemnation Is Justified

On page 463 a correspondent expresses the belief that engineers as a class are egotistical and delight in speaking unfavorably of their predecessors.

In many instances this is true, but more often the unfavorable comment is justified. If the truth were known, the shortcomings of the predecessor are due, not to his incompetency but to the reluctance of the management to supply the necessary material to keep a plant in proper running condition. Almost any engineer, however good he may be, will become discouraged when his requests for essentials to good service have been repeatedly denied by the shortsighted manager. Then he loses interest in the plant and things get worse instead of better.

The engineer who must tolerate such conditions long, eventually loses heart in all things. Such a situation breeds the attitude that precedes the loss of self-respect and of the approbation of his fellow men and induces the pessimism that precedes degeneration.

So when a man in this frame of mind assumes charge of a run-down plant when he expected to find it in good condition, and meets with opposition in his efforts to put it on a paying basis it is likely he will condemn his predecessor, who undoubtedly worked hard to improve it also.

In engineering, as in all channels of human activity, the drone persists. He deserves the condemnation he receives. A man taking charge of a plant left in bad condition by a shirk is justified in protesting.

In Restraint of Education

Eighty thousand children were denied their right to attend school all day at the opening of the fall sessions of the public schools of New York City. This is disgraceful, if not criminal. The school laws compel the daily attendance of children up to the age of sixteen, and prohibit their doing manual labor. What a shame, then, to deprive them of half the time they need to get beyond the pale of ignorance and illiteracy.

Thirty-four million dollars was apportioned the Board of Education of the second largest city in the world for the education of its children for 1912, and the sectarian and private schools lifted the burden of educating more than two hundred thousand children, and yet eighty thousand are unable to attend school full time. The Board of Education should use some of the money it now pays for what are aptly called "frills"—music, dancing, "art," "specialists," etc.—in renting temporary quarters and increasing its staff of teachers.

We hope this matter will be taken up by the Institute of Operating Engineers and the local operating engineering organizations. They realize what the young engineer of the future is losing; they know how the young engineer has to struggle today, because in his early youth he had no chance to properly learn the necessary three R's. These organizations should voice a loud protest against an injustice that is working a hardship the gravity of which is almost impossible to estimate.

Given the opportunity of studying at the age when his mind is most receptive and his help as a bread-winner can best be spared by his parents, the boy will not suffer humiliation when he goes to work. He will not have to burn the midnight oil in his endeavor to acquire the education denied him at a time when he might far better be gaining strength in sleep and healthy recreation.

"To earn more, learn more" will prove a feeble slogan indeed if the local organizations in New York City do not demand the education for the city's children that is their right. And if this condition obtains in other cities, even in a lesser degree, its seriousness should be given cognizance and remedial measures taken to correct it.

In American schools there are nearly seven hundred foreign students, Chinese, Koreans, Turks, Chileans, Russians, Finns, Ceylonese and others. The high cost of living here is no deterrent to the foreigner's ambition to acquire knowledge that will make him a useful citizen in his own country and a credit to us.

We are glad to be enlightened by one of our esteemed contemporaries that "a turbine is composed of two essential parts, first the fixed part or cylinder, and second, the moving part or rotor."

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

The Engineer and His Predecessor

As a boiler inspector I meet so many engineers ready to dissect the record of their predecessors that I am inclined at times to believe that long association with cranks and eccentrics, not to mention blowing apparatus, has made engineers as a class very egotistical.

Even in POWER, sometimes the correspondent begins his letter by relating the deplorable conditions he found when he took charge—the pumps were out of order, engines out of line, boilers full of mud and scale, etc. Then he tells what wonderful changes he brought about by a few simple expedients. Human nature is much the same the world over, and most of us like to be complimented. Some go so far as to pat themselves on the back when they accomplish something notable.

The average engineer has a hard enough time without his successor throwing "bricks" at him. I have seen thoroughly competent men so held down by their superiors that the plant could not be kept in even fair condition. When repeatedly refused supplies and repairs, the best men are likely to become indifferent. Sometimes a superintendent or manager is convinced of the justness of the engineer's requests, but is too hard-headed to relent and lets things go along until the engineer quits in disgust. Then the new engineer gets everything needed to put the plant in order.

It is true there are engineers who take no interest beyond "putting in" the day, but they are few, and when an engineer's letter tells of exceeding his predecessor's record in fuel and other expenses, I wonder if there are not other reasons than incompetency.

A. C. TERLENE.

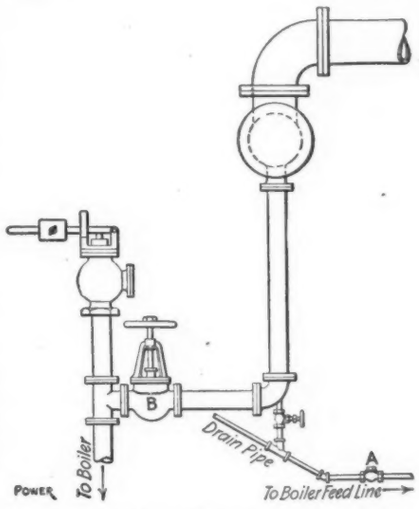
Chattanooga, Tenn.

What Broke the Stop Valve?

This plant has three horizontal return-tubular boilers, 150, 100 and 75 hp. respectively. No. 1 boiler had been cleaned and inspected and was steaming again with No. 3, while No. 2 was out of service to be cleaned and inspected.

When I first went into that boiler I noticed that the 5-in. stop valve was leaking enough to be annoying when cleaning. I notified the chief engineer, who tightened the valve down with a big monkey-wrench, and the leak stopped. At the time, the boiler had been off for 24 hours and had cooled. The boiler was then cleaned and found in good condition by the boiler inspector and was afterward made ready to be connected with the others.

The chief always connected the boilers himself. Before going on top of the boilers to connect No. 2 he closed the steam valve on No. 1. The drain-pipe connection was as shown. The check valves, one of which is shown at *A*, were leaking more or less and as the stop valve *B* had been screwed down tight when the boiler was cool, the chief had to use considerable force with a big wrench to open it, which occurred suddenly, opening the valve wider than he expected.



SHOWING BROKEN STOP-VALVE ON STEAM MAIN OF BOILER

A terrible racket indicated that something had gone wrong. The body of the valve burst, hurling the chief against the wall. With presence of mind, he crawled toward the front of the boiler, but fell over its edge upon the ashpit-door and broke a hip bone, besides being scalded badly. Eight months afterward he died.

A boiler inspector stated that the cast-iron body of the stop valve had a flaw in the casting. He ordered the drain pipe which was run into the feed line changed into the blowoff pipe. A tee was placed behind the blowoff valve and a 1½-in. pipe screwed into it, which was connected with the 1-in. valves on top of the boiler. The inspector said that these valves should be left open all the time. There was a valve put in the vertical 1½-in. line, which was kept closed. Each time the boilers had been blown down this valve was opened for a little while to let the condensate out of the line. When a boiler was connected the engineer opened this valve before he connected the boiler and closed it afterward. When No. 1 was shut off, the gage showed about 90 lb. and just that much on No. 2 and No. 3.

Why the chief shut off No. 1 I do not know. Do POWER readers think that closing the valve on No. 1 had anything to do with the explosion? What was the real cause of the trouble? Was it the wrongly connected drain pipe or tightening down on the valve when the boiler was cool? The valve had been on the boiler about 15 years. The boiler inspector called our attention to the thickness of the casting of the valve body, which was ⅛ in. thinner where it probably started to give way than it was in other places.

WILLIAM L. KEIL.

Philadelphia, Penn.

Hydraulic Elevator Indicator Diagrams

Indicator diagrams from hydraulic elevators are taken or published so seldom that those shown below should be of interest.

The diagrams were taken from a 22x 90-in. elevator cylinder operating under a tank pressure of 100 lb. The load was

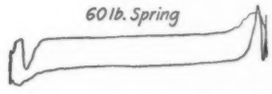


FIG. 1 Partial Stroke

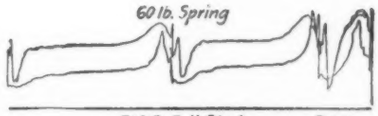


FIG. 2 Full Stroke

DIAGRAM FROM CYLINDER OF HYDRAULIC ELEVATOR

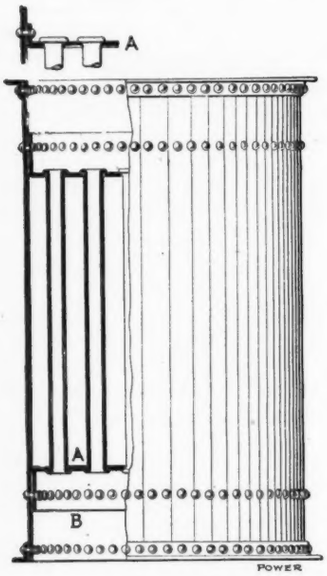
the same on the up as on the down motion; they are friction diagrams only. Fig. 1 is a record of only a part of the stroke. Fig. 2 represents a full stroke and shows that a stop was made at a little less than half stroke. It also shows that the pump did not maintain full pressure throughout the stroke.

HARRY D. EVERETT.

Fort Apache, Ariz.

Saving Partly Injured Condenser Tubes

The illustration shows how a set of condenser tubes were saved. These tubes are of bronze and very expensive. The beading had given out from constant expansion and contraction and to save the condenser the tubes were all removed from the old heads, the ends measured and cut off square to an exact length. Then two new condenser tube heads were



CONDENSER REPAIRED BY SHORTENING TUBES

made with extended flanges, as shown at *A*. The distance from *A* to *B* was made great enough so that the tubes could be cut off and the heads riveted back in place, using the old rivet holes in the outer shell, thus saving the outer shell as well.

This condenser is used for cooling or condensing in an ice plant. Several of them were saved in this manner and do the work as well as new ones.

C. R. McGAHEY.

Baltimore, Md.

Corliss Versus Four Valve Engine

Being much confused over the following, I would appreciate answers from those interested.

How is it that the four-valve nonreleasing engine is represented to show as good economy as the Corliss releasing engine—at a speed of 225 r.p.m.? Does the clearance not have to be increased? How is it explained that clearance is regarded as almost a total waste? Have not nearly all the improvements in Corliss engines been along the line of reducing the clearance?

The diagram factor of a good Corliss engine is about 95 per cent. and of a four-valve nonreleasing engine only about 87 per cent. How does this affect the economy of an engine? Would you not have to have a larger cylinder in a four-valve engine to do the same work as a Corliss? The four-valve engine makers claim that the steam is superheated by this wire drawing, but with the design and operation I fail to see how it is possible to guarantee the performance and economy of a four-valve engine to equal a Corliss.

Is it possible to make a showing of low steam consumption per indicated horsepower with the four-valve engine and still not do it? Does not the valve movement depend on the time element in the four-valve engine and in the Corliss on the load developed; does not this affect the economy? Is not the wear on a four-valve nonreleasing engine very rapid?

How does the angularity of the connecting-rod affect the diagram of an engine or bear on the mean effective pressure of the crank end? On a four-valve engine it will be noticed that the connecting-rod is very short as compared with a Corliss.

I realize that I am asking for considerable information, but there are many others who would appreciate a discussion on these questions.

B. E. DONOVAN.

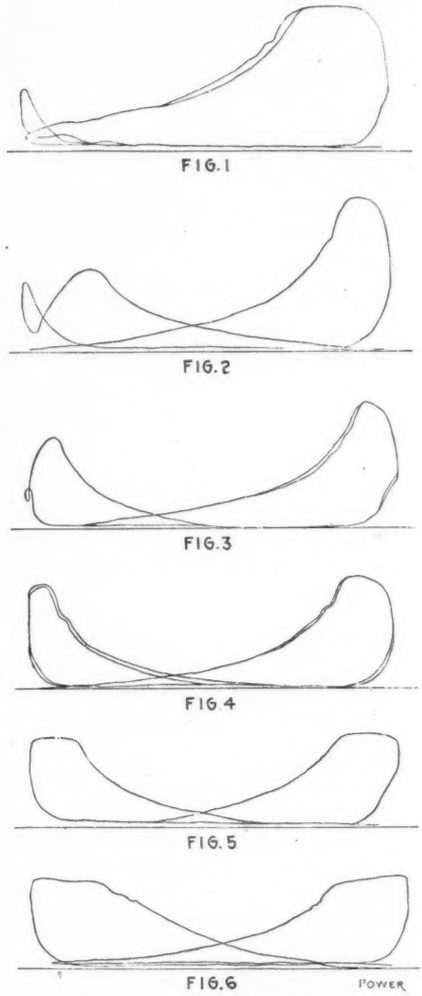
Omaha, Neb.

Adjusting a Brown Engine Valve Gear

A mixed-up valve-gear had caused an engine to be condemned as "no good." When diagram Fig. 6 was taken it was as good as new. Some unknown means, apparently continual tampering with the valves, caused the steam pressure to be raised from 80 lb. to 125 lb. to get the engine to do even a small portion of the shop load. The valve-gear had numerous scratch-marks, one of which I could use, so I put on the indicator and obtained diagram, Fig. 1.

I then set about to get the proper steam lap and length of valve stems. The old method of getting the lengths of the valve stems is to take off the valve chest and valve and measure from the top of the guide-block to the bottom edge of the bottom port. The valve stem is the length from the bottom mark on the stirrup block to the bottom of the valve. These should correspond when the valve stem is the right length. The mark made by the builders can be seen by taking off the guide-block, and is found scratched on the engine bed. If the valve is down on the bottom of the steam chest the valve-stem end will come even with it, or it can be made to do so by screwing the stem in or out of the valve. I used the indicator pipe to get the puff of steam, noting the marks at the same time. With a bar I raised the valve until I got steam from the indicator and noted the distance the valve stem had traveled. The engine was known to be practically steam-tight. Changing the valve stem until the travel corresponded to the marks on the stirrup block, having now got the laps, I proceeded to set the valves.

Fig. 1 showed the head-end events to be late. I advanced the head-end eccentric to get earlier admission, and obtained Fig. 2. This caused the opposite end to shorten its cutoff automatically.



BROWN ENGINE DIAGRAMS SHOWING RESULT OF VALVE ADJUSTMENT

I next advanced the crank-end eccentric and got an earlier opening, as shown in Fig. 3. Then I threw both exhaust eccentrics back to delay their closing, giving less compression, and obtained Fig. 4.

I next proceeded to equalize the cutoff, making the crank end $\frac{7}{16}$ in. and the head end to correspond by loosening the setscrews and pushing the taper pin in and out until I got a very close adjustment. There are only setscrews on the crank end, no taper pin being used. After the changes, a load was put on the engine and diagram, Fig. 6, was taken with 80 lb. steam. After blocking the governor

a trifle lower than its highest position, I so adjusted the trip shaft that by turning the top of the handwheel away from the cylinder the valves would not pick up enough to uncover the steam lap in case the engine tried to race.

This engine had been running with a large amount of lap on the steam valves, causing most of the eccentric's throw to be taken up before the valves were open and decreasing the range of cutoff. By decreasing the lap, the load was carried with greater ease and economy.

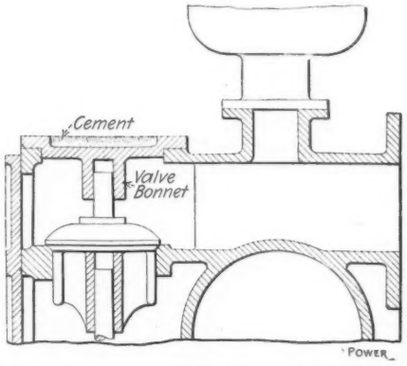
I would like the reader's comment on the diagrams.

A. C. WALDRON.

Revere, Mass.

Keeping Valve Chamber Covers Clean

One of the little jobs done to lessen the labor of cleaning in the plant is shown below. Each of the valve-chamber bonnets of the feed and stoker pumps had



CEMENT-FILLED VALVE-CHAMBER COVER

a depression about 2 in. deep and 3 in. in diameter, which afforded a resting place for oil, water and dirt. There were 96 of these unsightly holes and a visitor's suggestion to fill them with portland cement was adopted. A little manganese dioxide was added to color it black, and when it was painted it looked like the solid metal.

T. W. ZERMEIN.

Brooklyn, N. Y.

A Troublesome Injector

The makers of our injector specify that the steam, water delivery and suction pipes must be of 1½-in. diameter. Its capacity is 55 litres (12.1 gal.) of water per minute, and it is supposed to start at any pressure between 45 and 120 lb. It will lift the water all right and allow it to escape at the overflow and will inject water into any of the boilers when there is no pressure in them, but the moment a boiler is under anything above 30 lb. pressure the injector will not work. It has been sent back to the makers and they report it in working order. The lift from the supply tank is 6 ft., as shown, and the temperature of the water is 59 deg. F.

The injector is for use only on the 90- and 120-lb. boilers, as per specification, and has never been tried on the 195-lb. boiler. The injector takes steam from the main header, which is common to all three boilers, but only takes steam from one boiler at a time because no two boilers are in service simultaneously. I tried giving the injector steam from the 120-lb. boiler and injecting water into the 90-lb. boiler while the pressure in it was being increased, but it would not work. The same thing happened when I tried it with steam from the 195-lb. boiler and injecting water into the 120-lb. boiler, and again when I tried injecting water into either the 90- or 120-lb. boiler by using steam from the same boiler into which the water was being forced. With our duplex pump or engine pumps no trouble is experienced, so it cannot be due to faulty piping unless it is that there are too many ells and tees in the feed line. The bends in the line at the well have a radius of 10 times the pipe diameter. The distance from the injector to the check valve on the 120-lb. boiler is 16 ft., and to the 90-lb. boiler check valve, 42 feet.

Can readers tell me what causes the trouble?

E. S. WYLDE.

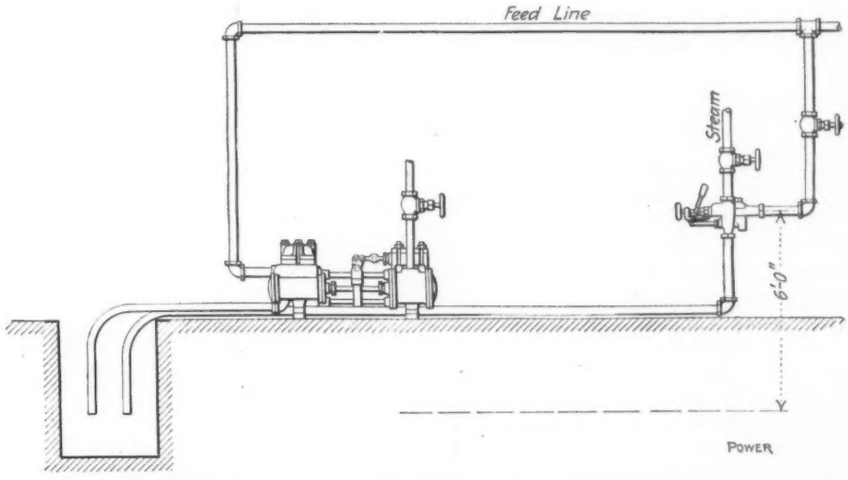
Pinerolo, Italy.

The Tilt Trap as a Boiler Feeder

Some consider the tilt trap the most efficient and economical boiler-feeding device. It may be when condensation must be removed from long steam lines, heating systems, etc., and returned directly to the boiler. It is claimed that the tilt trap is equally efficient whether the initial temperature of the feed water is 40 or 250 deg. and that its operation will satisfy all conditions and mean a considerable saving of coal, even though the existing boiler-feeding apparatus may be of the highest order with respect to the saving of heat units in the available exhaust steam.

I do not believe that the operation of tilt traps for boiler feeding means all "velvet," and would be interested in the opinions of POWER readers who have given this matter considerable study.

Operating engineers insist that the injector is a "steam hog" because it "pulls the steam down" and if it does there must be some reason for it. However, the injector has a very high thermal efficiency and since the heat in the steam used is returned to the boiler in the feed water it ought to be rather efficient and economical as a boiler feeder. But supposing that the injector is a real "steam eater," would not the tilt trap come under the same heading? Like the injector the steam trap depends upon live steam for its operation, and both may be classed as live-steam feed-water heaters. This brings up the question whether it is desirable to use live steam for heating feed water when exhaust steam is available for that purpose. If a tilt trap is installed to replace a steam or power pump, would greater economy result?



DISCHARGE AND SUCTION PIPES OF PUMP AND INJECTOR

The following questions have a direct bearing upon the economic operation of tilt traps for boiler feed:

Will the evaporation be the same whether the feed water is admitted regularly or intermittently, assuming that all other conditions remain exactly the same?

Would the intermittent admission of feed water retard the circulation, especially in a tubular boiler having the feed-water intake through the blowoff connection? And if the circulation is retarded, would it not affect the heat transmission which in turn would affect the evaporation and the coal pile?

The operation of tilt traps is such that the feed water is discharged at intervals.

A. A. WICKLAND.

Chicago, Ill.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Purchased Current for Summer Months

The arguments of W. A. Blonck, of Chicago, in favor of shutting down office-building power plants during the summer months and purchasing electrical energy from a central station and the editorial criticism which appeared in the Aug. 20 issue, interested me.

As I disagree with Mr. Blonck on some points and POWER on others and agree with both in still others, I wish to give what I consider an impartial statement of some of the more important factors entering into this problem.

Every office building presents a separate problem, and whether a power plant is more economical than a heating plant and central-station electric service depends entirely on the many and varied factors that enter into the particular building and can only be determined by an unbiased study of the cost of operation with and without an isolated plant. One thing certain is that few office buildings could afford to maintain their own plants if exhaust steam was not available for heating purposes during the winter. Also quite certain is that during the summer months making electricity costs as much if not more than purchasing it from a central station. As to which is more economical, isolated plant the entire year or isolated plant during the heating season and central-station service during the summer, is again determined only by local conditions. For each building the question must be decided on its own merits.

Mr. Blonck's statement that an isolated plant takes four tons of coal to develop the same amount of electrical energy that can be produced with one ton in a central station is absurd. The efficiency of the boilers would be about the same in either case. The efficiency of the engines might be 50 to 75 per cent. in favor of the central station, which would be offset to a small degree by the losses in the distributing system, but at the worst the isolated plant would hardly burn more than double the coal for the same amount of electrical energy. Where the central station gains is in its ability to burn cheaper grades of coal, the special price obtained by buying in large quantities and more economical systems for handling the coal and ashes; also, in many plants the lower cost of labor due to the use of stokers. Mr. Blonck's statement in regard to the elimination of radiant heat from the boilers, engines, piping, etc., is well taken. Almost all office-building power plants are regular Turkish baths during the hot summer months and an ounce of prevention, by having no heat to radiate, might be worth the pound of cure suggested in the foreword in the Aug. 6 issue.

POWER states that during the summer months electric elevators and motor drive for all pumps and auxiliaries would be required, and no exhaust steam from these pumps would be available during the winter for heating the feed water and that the steam would have to be taken from the engines. Most office buildings have electric elevators, and if they have hydraulic elevators, the elevator pumps can be changed to electric. The only other pumps that would have to be replaced by electric are the house and fire pumps (very often the same pump is used for both purposes) so that this is not such a serious objection as it might seem at first. As for the loss of exhaust steam, even if all electric pumps were required, the energy has to come from the boilers whether it goes direct to the pumps as steam or first to the generating unit as steam and then to the pumps as electricity. Also as the engines are more efficient than steam pumps it would be cheaper to operate the electric pumps unless the heating demands required more live steam from the boilers than the difference between that necessary to generate the electricity in the generators and to operate the pumps. In the latter case the steam pumps would be cheaper as the initial and maintenance costs are less.

The point that many buildings are fitted with absorption refrigerating systems which require exhaust steam is well taken, and such buildings would hardly find it profitable to use central-station service at any time.

The labor question is probably the most important item entering into the problem and would go a long way toward making the final decision. The statements by POWER on this point admirably cover the ground.

While central stations would probably prefer to have a yearly contract it should be to their advantage to increase the summer load by giving office buildings especially attractive rates for this kind of service. The summer load of any central station is much lower than the winter load, due to the exodus of people from the city, and the longer hours of daylight.

Now that all is said it still remains a problem for each building to solve independently, taking into consideration the points mentioned above.

No doubt in some cases a great saving in the yearly expense could be made by following the method suggested by Mr. Blonck, but in other cases just the reverse would be true. Still the question is so important that it would pay all office power-plant engineers to take this idea under consideration and see how it would affect their own plant.

EDMUND LEAVENWORTH.

Brooklyn, N. Y.

Back Water from Open Heater

Relative to the question by G. W. in the Aug. 13 issue, I would advise him that all open heaters have an overflow connection which takes off water at a lower elevation than the steam inlet; so that even if the float valve failed to work there would be no chance of water getting into the engines from this source.

THEODORE HAIGHT.

Brooklyn, N. Y.

Friendliness and Familiarity

One is not supposed to criticize nor to comment on the articles known as "editorials," because the editor is supposed to be the last word on any subject. Yet, when one sees where an editor has gone wrong, it is only a "duty well done" to have pointed out the error of his ways.

The article to which I take exception is found on page 94, July 16 issue, and entitled "Know Your Employees." Your article starts with the statement "that it was once believed, etc.," and that old-time belief, though wrong as regards the "dignity" part of it, was right as regards the discipline. When a manager, superintendent, or even chief engineer gets the habit of being familiar with, or allowing the men under him to become familiar, right then and there the wheels of good management start to clog, and in time a new crew, or a new head man will become necessary.

Of course the manager, or superintendent should go into the plant, or factory frequently, see how things are going and if all is not well, should call the head of

the visited department into his private office, and talk the matter over with him; and never jump on one of the crew, nor the head while in the presence of the men.

Man is a very peculiar sort of creature, and while we may, and do, all blow and bluster, yet we know way down in our hearts that we are inclined to take advantage always of each and every point. Should the superintendent come to the plant, and allow me to get to calling him by some given nickname, or to slap him on the back, and invite him to go drink with me, then he would either lose his respect for me, or he would be unfit for the position held by him, because were he to allow this, it would be but a matter of a very few days or weeks until I would lose my respect for his authority, and then I would be worse off than if he had been strict, and formal and shown no friendliness toward me.

The manager of the plant where I am employed as chief engineer is one of the best men I have ever known. One or two things in our relations, however, are peculiar. As a manager, he is as strict and unbending as an army officer and holds me to account for everything that takes place in the plant. He does not jump on my crew, but as he should, calls me into his office and "stands me on the carpet." I respect him for this and he knows it. One of the other departments had a head man, who, because the manager asked him a few questions about his private affairs in a kindly manner, took it for granted that he had a "stand in" with him, and so became negligent in his work (as all men will do, should the management allow themselves to become familiar) and in two weeks was calling him by his given name. The third week he was so friendly that he attempted to slap the manager on the back. As a result he was shortly looking for another job, while the manager felt that he could not afford to get close to his men.

In the army, discipline must be maintained, and here or in a civil office when a superior gets so that his men know him too well, it is bad both for the employee and the employer.

JOHN PIERCE.

Alva, Okla.

Air Compressor Indicator Diagrams

The indicator diagrams offered for comment by C. E. Anderson in the June 18 issue, interested me. Instead of the air-cylinder diagram, Fig. 6 (here reproduced as Fig. 1), I would have preferred to have had the real, full-sized card. If it was really taken with a 40-lb. spring, and the air delivery pressure 75 lb., then it was about as long as any standard indicator will make.

I am continually more certain that all indicator diagrams are not absolutely truthful in the story they are supposed to tell. The number of diagrams which do not carry some suggestion of incorrect indicator action is not as large as it might be. The drum movement should be actually coincident with that of the piston, and this it too frequently is not. A connection between the drum and the crosshead should be as absolutely non-elastic as that of the connecting-rod with the crank, and the necessary flexibility of the former connection should not be permitted to excuse it. The indicator should be as rigidly mounted as a New York skyscraper; there should be no elasticity and no lost motion anywhere in the connections. The drum spring should have sufficient tension to command the drum inertia, and friction should be nowhere in evidence.

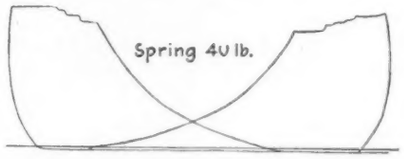


FIG. 1

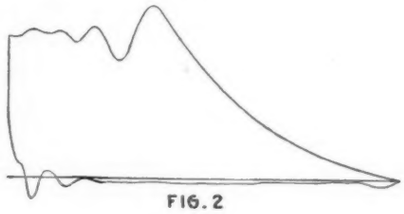


FIG. 2

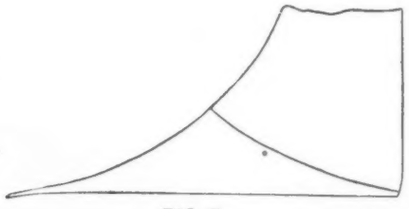


FIG. 3

DIAGRAMS FROM AIR COMPRESSOR

This diagram, Fig. 1, was taken from a slow-running machine, 50 r.p.m., yet it seems to be lacking in the precision of movement which is so essential. In air diagrams the reëxpansion line is very important, and as it is made so quickly, or in such a small part of the total drum movement, precision of movement is here most essential; where it is lacking the inaccuracy is noticed at once.

I notice that the drum reached the limit of its travel, ostensibly representing the end of the compression stroke, when the pencil was at *a*. But the card reveals that reëxpansion, representing the beginning of the return stroke, had actually begun before that, and the pressure in the end of the cylinder had fallen more than one-third before the indicator began to record the return stroke at all; of course, the indication was incorrect. That this is a frequent fault in air diagrams does not excuse it, because cards can be and are taken, on faster-running machines where the beginning of the return drum movement and the beginning of the reëxpansion curve occur coincidently at the upper corner.

The indicator inaccuracy appearing in the reëxpansion line of Fig. 1, was due to the arrival of the indicator drum at the end of its travel, and then the beginning of its return too late for the compressor piston. The latter had evidently begun its return, and the pressure in the clearance space had dropped to a considerable degree before the drum began to move.

Fig. 2 is a card, typical of a dozen which recently came to me, with a slightly different peculiarity. Here the indicator drum seems to have reached the end of the compression stroke on time, and the pencil shows the correct position for the start on the return stroke, only the drum does not start promptly. The compressor piston starts and the pressure in the clearance space drops nearly to atmosphere, and then the drum starts suddenly as shown by the sharp crook. The reexpansion line should have been a smooth curve clear down to the suction line, beyond which point the indicator action seems to have been normal.

Nothing is told about the make and style of the compressor or the type of valves used, especially the inlet valves which seem to be positively operated, as shown by the compression line of Fig. 1, where the pressure remains below atmosphere for the first quarter of the stroke, and then the intake valve closes quickly and compression begins. This control of the inlet valve and the closing of it at varying points of the compression stroke, is the arrangement employed in certain compressors for varying the volume of air compressed according to the varying demand for the air. If the inlet valve is closed by positive mechanical means it also might be opened in the same way, and it might be adjusted to open too soon, which would give the peculiarity spoken of in the compression line of Fig. 1, except that at the moment when the compressor center was passed the drop should have been more decidedly vertical than it was.

A vertical straight line for some distance should have been expected in the case. Notice the vertical drop of the reëxpansion line in Fig. 3. This was not caused by a prematurely opened inlet valve but by a very leaky piston, but the vertical drop should have been practically as abrupt with the open inlet valve, if that was the actual condition.

I hope that Mr. Anderson will tell us all about it.

FRANK RICHARDS.

New York City.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Increasing Pressure of Forced Draft

How can the delivery pressure of forced draft from a fan blower be increased? Cannot the pressure and volume be raised by increasing the speed of the fan shaft?

J. M.

Pressure can be increased by partly closing the outlet but the volume of free air delivered will be decreased. Both pressure and volume will be increased with increase of speed, though the pressures will not be in proportion to the speed of the fan, but to the square of its speed. To increase the pressure 50 per cent. would require the fan to be speeded up to 2¼ times as fast; and to double the pressure, would require the fan to be driven four times as fast.

Do Not Wet Firebrick

Is any serious damage done to firebrick of a furnace by wetting down before pulling the fire?

F. H.

No serious damage may be done if water is confined to the ashes and clinker, but it is bad practice to wet down in such a manner that any water reaches hot firebrick, as it results in rapid failure of the furnace lining.

Miner's Inch

What quantity of water or rate of flow is a miner's inch?

G. H. C.

A miner's inch of water may be roughly defined as the quantity which will be discharged by a vertical orifice 1 in. square. The term originally signified a unit of measurement in designation of the size of apertures employed for gaging water supplied for mining purposes, regardless of kind or proportion of orifices. which were usually employed under heads ranging from 4 to 7 in. above the centers of the apertures. The average head employed is about 6½ in. and the discharge averages about 1.5 cu.ft. of water per min. per sq.in. of aperture. As the quantity of water passing through an aperture per square inch of area is modified by the proportions of the aperture, the velocity and head of water presented, the form of channel of approach, the shape of the edges of the aperture and freedom of discharge, the quantity represented by one miner's inch is very indefinite unless all conditions are stated. In view of the uncertainty, California and Montana have established by law that 40 miner's inches are equivalent to 1 cu.ft. per sec., making one miner's inch equivalent in those states to 1.5 cu.ft. per min.; while in Colorado 38.4 miner's inches is made equivalent to 1 cu.ft. per sec., or one miner's inch is equivalent to 1.56 cu.ft. per min. In many of the states, by common agreement, 50 miner's inches are assumed as equivalent to a discharge of 1 cu.ft. per sec., making the miner's inch equal to 1.2 cu.ft. per min.

"Cataract"

What is a "cataract" regulator?

F. H. K.

In single-acting engines the exhaust valve and the steam valve are not opened directly by the plug rod, but by a piece of mechanism called the "cataract," of the nature of a pump brake. Coming down from the name applied to a form of regulator used on early Cornish engines, in which motion of a rocking bucket alternately filling and tilting was employed for controlling the period of admission of injection water, the term "cataract" continued to be applied to hydraulic mechanism used for regulating the motion of engine valves and more recently to other forms of governors that operate by displacement of oil or other liquids.

Reactance and Impedence

What is the difference between reactance and impedence in an electric circuit?

T. P.

In direct-current work the difference in potential is equal to the current multiplied by the ohmic resistance, i.e.,

$$E = I \times R \text{ (Ohm's law)}$$

In alternating-current work, however, there is more than the straight ohmic resistance; there is self-induced electromotive force which opposes the impressed electromotive force. This is called "reactance." It is not in phase with the current; hence must be added vectorially to obtain the total resistance which is called "impedence," hence,

$$\text{Impedence} = \sqrt{(\text{resistance})^2 + (\text{reactance})^2}$$

Boiler Brackets

Why are present-day return-tubular boilers usually provided with two supporting wall lugs or brackets on each side, in place of three, as formerly?

G. H. P.

When three pairs of brackets are employed, expansion of the furnace walls or height of the bedding of the wall bearing plates are likely to cause the boiler to be mainly supported by the middle pair of lugs and thus throw excessive weight on the side walls of the furnace, making them more difficult to repair than when the boiler is supported on a pair of lugs near each end. When two pairs of lugs are used, in addition to affording better distribution of weight on the walls there is also the advantage of imposing less transverse strain on the boiler, from the weight of the boiler and its contents, as equal transverse strains would occur only if the lugs were placed at the ends.

Babbitt Metal

State a formula for making hard babbitt metal for engine bearings. What is 12, 1 and 1 babbitt metal and how is it made?

J. H. A.

A good, hard babbitt metal is made in the proportions of 88.9 per cent. tin, 3.7 per cent. copper and 7.4 per cent. antimony. Melt 12 parts of copper and add 36 parts of tin; reduce the temperature as soon as the copper is melted. Add 24 parts of antimony and 36 parts of tin, having the surface of the molten metal covered with pulverized charcoal to prevent oxidation of the tin and antimony. The alloy thus formed is to be remelted as required and used in proportions of 1 part of the alloy with addition of 2 parts of tin. "Twelve, one and one" babbitt is a tough white metal used for lining bearings, crankpin bushes, etc., and is composed of 12 parts of tin, 1 of copper and 1 of antimony. It is usually made by melting 6 parts of tin and 1 part of copper and separately melting 6 parts of tin and 1 part of antimony and mixing the alloys, the object of forming separate alloys being to expose only one-half of the tin to the high temperature of fusion required for first introduction of the copper and thereby subject the more highly oxidizable metals to as low temperatures as possible.

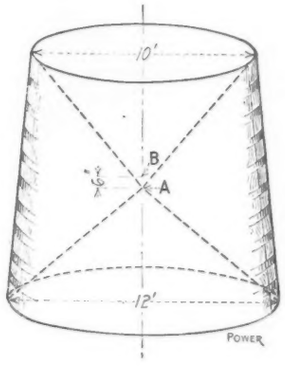
Study Questions

This Week's Questions
Last Week's Answers

(96) What is the available horsepower from an engine of 90 per cent. mechanical efficiency when the indicated horsepower is 85.6?

(97) It is found that six ells and seven tees, all for the same size pipe, have a combined weight of 33 lb., while seven ells and six tees weigh 32 lb. What is the weight of each ell and each tee?

(98) In a roof tank of the form shown in the diagram, a point *A* is found in the vertical axis, 6 in. below the mid-



height *B*, which is equally distant from all parts of the two circles formed by the intersection of the sides with the top and bottom (as along any of the dotted lines shown). The diameter of the top is 10 ft. and of the bottom 12 ft. How many gallons will the tank hold?

(99) The power factor of a 500-volt, three-phase induction motor is 0.85 when taking 25 hp. from the line. What will be the current in each phase?

(100) A grade 1000 ft. long has a rise of 50 ft. What horsepower is required to draw a load of 200,000 lb. up the grade in 1 min., assuming the friction to be 2 per cent.?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

---

(91) The absolute pressure corresponding to 175 lb. gage would be

$$175 + 14.7 = 189.7 \text{ } lb.$$

Perfect vacuum would be 0 lb. or 30 in. of mercury. The vacuum is not perfect by

$$30 - 26 = 4 \text{ } in.$$

and the absolute pressure corresponding to 4 in. is

$$0.49 \times 4 = 1.96 \text{ } lb.$$

Hence the total difference in pressure is

$$189.7 - 1.96 = 187.74 \text{ } lb.$$

(92) *A* riding twice as fast as *B* walks, reaches the end of the first mile when *B* has only gone half a mile and is still half a mile ahead of *B* when *B* reaches the bicycle, so that both reach the end of the second mile together. As the same is true of any even number of miles, *A* and *B* reach their destination at the same time. Each rides half the distance, 6 miles and walks 6. The riding speed being 8 miles an hour and the walking 4—the time taken is

$$\frac{6}{8} + \frac{6}{4} = 2\tfrac{1}{4} \text{ } hr.$$

(93) If the pipe is 9 in. thick its internal diameter is twice 9 in. or 1½ ft. less than the external, or

$$3\tfrac{1}{2} - 1\tfrac{1}{2} = 2 \text{ } ft.$$

If the pipe were solid its volume would be its length times the cross-sectional area. The area of a circle being

$$\frac{\pi D^2}{4} = 0.7854\, D^2$$

where D = diameter, the volume is

$0.7854 \times 3.5 \times 3.5 \times 16 = 153.938$ *cu.ft.*

Similarly the volume of the bore is

$0.7854 \times 2 \times 2 \times 16 = 50.266$ *cu.ft.*

Then the actual volume is

$153.938 - 50.266 = 103.672$ *cu.ft.*

and the weight

$$35 \times 103.672 = 3628.52 \text{ } lb.$$

(94) In an 8-pole generator there are four cycles per revolution. To obtain 60 cycles per second the generator must make $\frac{60}{4} = 15$ revolutions per second, or

$$15 \times 60 = 900 \text{ } r.p.m.$$

(95) By trigonometry the sine of the acute angle made with the base is equal to the altitude divided by the hypothenuse. Since the hypothenuse is equal to the square root of the sum of the squares of the other two sides it equals

$$\sqrt{28^2 + 35^2} = 44.82$$

Then the sine equals

$$\frac{28}{44.82} = 0.62472$$

From tables of natural trigonometrical functions the corresponding angle is found to be

38 *deg.*, 39 *min.*, 42 *sec.*

As the sum of the acute angles of a right-angled triangle is 90 deg., the other acute angle is

90 *deg.* — 38 *deg.*, 39 *min.*, 42 *sec.* = 51 *deg.*, 20 *min.*, 8 *sec.*

Erratum: An error in the location of the decimal point appears in the answer to Study Question No. 79 in the Sept. 3 issue. The volume of a pound of water is 0.016 cu.ft. instead of as given and the answer should have been 8.375 lb.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

A contemporary calls New York City's 55-story building a "sky-scratcher." This probably accounts for so many people itching to climb to the top of it.

It costs 56c. to stop a 1500-ton train running 15 miles an hour, says a railroad journal. Costs more than that before an exploding boiler is stopped.

DORAN—Who is ut put th' 'con' in economy, Terry

HORAN—An' who is ut t'rew th' fish in efficiency, Jawn?

Time! No hitting in the clinches!

Your scribe could find nothing of interest last week at Knuckel & Funnibone's fertilizer plant except that Guy Lines had two feet taken off and Derrick had a stiff leg.

A Western paper records a somewhat painful and embarrassing accident to Will Brown, a South End boy, by saying that "he was burned in the South End by a live wire." Undoubtedly, friend William will stand around for some time. The rest of the scholars may resume their seats.

F. Tennyson Webster has worked the poetic muse and made her give up the following:

TEN LITTLE ENGINEERS

Ten little engineers running a turbine;
One lost his vacuum; then there were but nine.
Nine little engineers figuring water rate;
One fell in the test tank; then there were but eight.
Eight little engineers worked till half-past 'leven,
One dropped in the flywheel; then there were but seven.
Seven little engineers in an awful fix!
One blocked the safety valve; then there were but six.
Six little engineers in a grimy hive;
One asked for 60 bucks; then there were but five.
Five little engineers strutting 'round the floor;
One broke the governor; then there were but four.
Four little engineers taking down a tee—
Took off all the nuts at once—then there were but three.
Three little engineers cleaning out a flue;
Along came a back draft; then there were but two.
Two little engineers having lots of fun,
One leaned on a live switch; then there was but one.
One little engineer stayed there all alone,
Till the owner bought his power—now there are none!

Keeping Track of Things

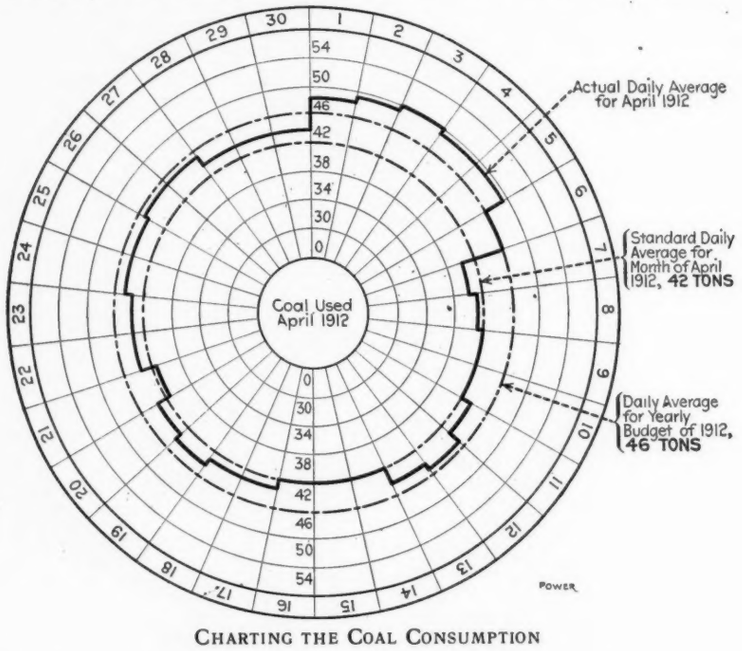
J. C. Jurgensen, president of the Institute of Operating Engineers, has made his success by keeping and improving records. In the last issue of the *Bulletin* of the institute is described how an engineer with no apparatus can chart his course, tell whether he is drifting into extravagance and be put on guard against extraordinary losses indicated by abnormal consumption by means of a circular chart system which Mr. Jurgensen uses.

In order to explain the method of use and the application of this chart, there is shown on the accompanying chart a coal-consumption curve for the month of April with its table of figures. The table has four columns, one for the date, one for the tons used each day, one for the total tons used to date and one for the daily average to date. There are three significant curves on the chart, the daily average as figured from the budget, the standard daily average and the actual daily average to date for the month.

The budget is the amount of coal that is allowed for use in a certain period. By dividing the total tons thus given by the number of days in the period, "the daily average shown by budget" is found. If the employers do not specify a certain number of tons for a certain period, the chief engineer can fix his own budget. It is the duty of every operating man to see how much he can save on the budget and to do this there must be fixed a certain standard, adherence to which means such a saving. The operating engineer after studying the conditions should fix a standard for his men to work by and to try and better. This standard will vary from month to month and should be fixed after a careful study of the records of the previous months of the period. It is on the bettering of this standard that the payment of a bonus is often based. Now two standards have been fixed for everyday use, the standard as figured from the budget and the standard as figured from previous records in conjunction with the budget. The first is fixed once for each period, year or half year as the case may be, and the second is fixed once for each month.

As soon as the chart is drawn up, the standards are put in with red ink, and the amount of the standards written beside them, thus placing at hand all necessary data so that the chart tells at a glance just how the daily consumption stands as compared with previous records. The broken curve is for the accumulative daily average. It is plotted day by day from the figures in the table. Coal used for any day is entered opposite the date in the second column and added to the total in the third column, then the third-column figure is divided by the date of the month and the result is the accumulative daily average to date for the month. After entering the figures in the table and drawing the daily line on the chart one can see at a glance how the day's run was made. If the consumption was too high, if the daily average is creeping up or if there is a large variance from running conditions it becomes apparent and one can investigate and remedy it immediately. The curve may be kept in any convenient unit, for instance, if there is no scale upon which to weigh the coal or ash the record can be kept in the number of wheelbarrows of coal or in the number of cans of ashes.

Date	Tons of Coal Used	Tons Used to Date for Month	Daily Average for Month	Date	Tons of Coal Used	Tons Used to Date for Month	Daily Average for Month
1	48	48	48	16	50	673	42
2	50	98	49	17	55	728	43
3	52	150	50	18	48	776	43
4	45	195	49	19	52	828	44
5	49	244	49	20	35	863	43
6	30	274	46	21	15	878	41
7	10	284	40	22	60	938	43
8	45	325	41	23	58	996	43
9	48	373	42	24	55	1051	44
10	51	424	42	25	58	1109	44
11	52	476	43	26	60	1169	45
12	60	536	45	27	40	1209	45
13	35	571	44	28	20	1229	44
14	12	583	42	29	45	1274	44
15	40	623	42	30	50	1324	44


Actual Daily Average for April 1912
Standard Daily Average for Month of April 1912, 42 TONS
Daily Average for Yearly Budget of 1912, 46 TONS
Coal Used April 1912
POWER

CHARTING THE COAL CONSUMPTION

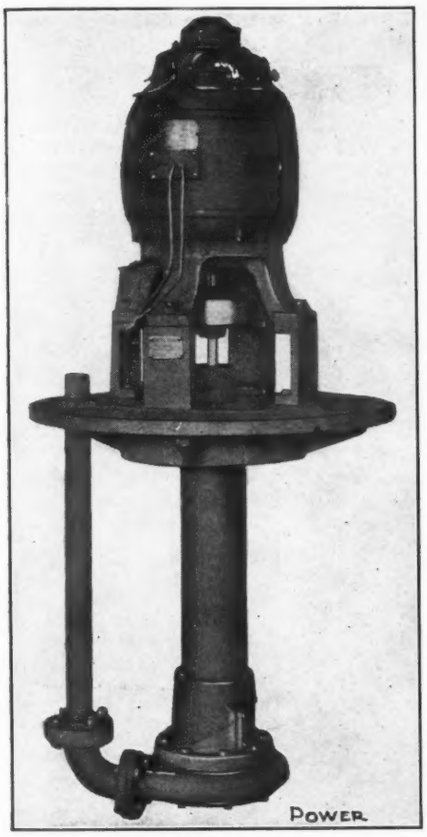
There is another chart which lends itself very nicely to power-plant work and that is the chart upon which are plotted the tons of coal used per day and the tons of ash removed that day. By direct comparison one can see from this chart how the firemen handle the furnaces each day and whether the coal is of a better grade or not, and by measuring the distance between the two curves can be found directly the number of pounds of combustible that were used. Where there are three watches in each day's run, the space for days on the chart may be divided into three spaces and the records of each watch plotted in these spaces and then the efficiency of each watch becomes apparent. This chart can be applied to cost of repairs, cost of salaries, material used, hours machines were in operation, ash removed, coal used, oil used, average loads, water used and in many other ways. Once one learns to keep and study his records, from the chart as described, he will find many ideas for its use springing up and will be surprised how, by a small amount of watching and studying, the costs will be kept lower and better results obtained without going to the expense of purchasing elaborate instruments and hiring men to tend them.

A Motor Driven Centrifugal Sump Pump

The outfit, shown herewith. consists of a vertical motor directly connected to a single side-suction pump, that is connected to a cast-iron pit cover by a rigid pipe column. This cover also acts as a support for the motor pedestals. The shaft is inclosed by the column which connects the pump to the cover and is therefore protected from the liquid in the pit. A removable plate on the flange which connects the pump and sup-

porting column permits inspection of the stuffing-box.

The electric motor is controlled by a starting device, actuated by a float in the sump. When the liquid rises to a certain level and the float is lifted enough to close the switch the motor is started. It continues to operate until the sump



MOTOR-DRIVEN CENTRIFUGAL PUMP

is nearly empty, when the float drops back to the switch-operating position.

For service where electric current is not available, a similar pump has been developed, equipped with a pulley for belt drive by any available power. This pump is manufactured by the Goulds Manufacturing Co., Seneca Falls, N. Y.

Mueller-Cash Reducing and Regulating Valves

The H. Mueller Manufacturing Co., Decatur, Ill., makes a line of reducing and regulating valves for all kinds and conditions of service. Those illustrated in the accompanying figures represent a part of that line.

Figs. 1 and 2 show the single-seat self-contained valve for service in connection with water, steam, air, gas, oil, etc. It is especially adapted for use with water where considerable reduction and close regulation are required and for steam-heating systems down to any pressure as low as 5 lb. absolute.

FIG. 1. THE MUELLER-CASH SINGLE-SEAT VALVE

The principle upon which this valve operates is as follows: The pressure on the discharge side of the valve acting upon the diaphragm *A*, Fig. 2, is opposed by the spring *B*, the tension of which may be adjusted by turning the screw *C*. As the pressure on the discharge side falls the spring *B* extends and through the pressure plate and pusher posts *D*, raises the disk off its seat. The small spring *E* furnishes the pressure to seat the disk against the difference in pressure between the admission and discharge sides of the valve. Where necessary a pop safety valve may be installed on the cap *F* to prevent excessive pressure on the

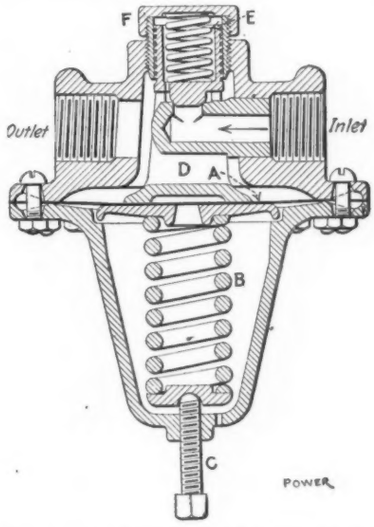


FIG. 2. SECTION OF THE SINGLE-SEAT VALVE

discharge side caused by any obstruction lodging on the seat.

The valve shown in Figs. 3 and 4 may be used as a pump governor, for general power purposes, on blower engines and as a reducing and regulating valve on water, steam, air, gas, oil and similar services with low, intermediate or high initial pressures reducing to low or intermediate delivery pressures.

This valve has a double outside spring which acts against the pressure in the

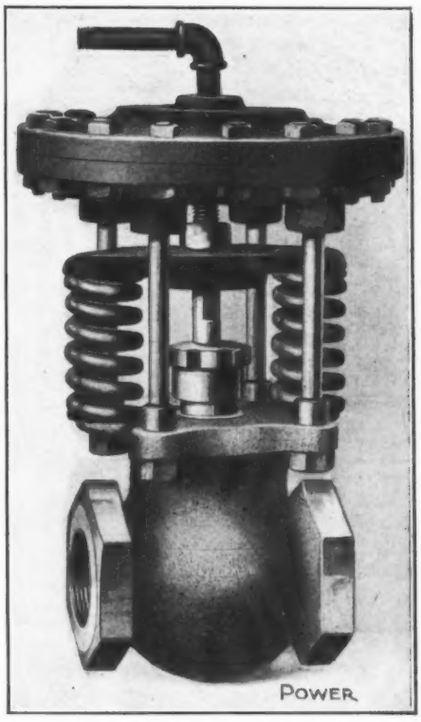


FIG. 3. DOUBLE OUTSIDE-SPRING VALVE

diaphragm chamber *G*, Fig. 4, which connects with the discharge side of the valve. Stem *H* and nut I adjust the tension.

Figs. 5 and 6 show the reducing and regulating and balanced relief valve

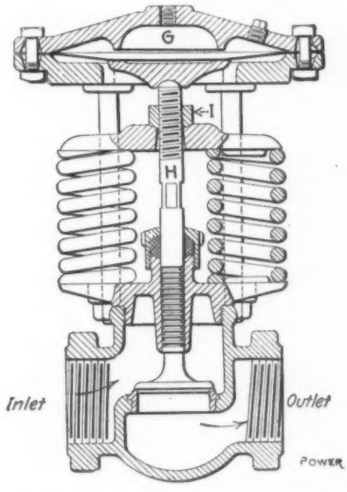


FIG. 4. SECTION OF THE DOUBLE OUTSIDE-SPRING VALVE

which is made for use on very exacting service. This is identical in construction with that shown in Figs. 3 and 4, except that it is controlled by a small sensitive

pilot or auxiliary valve which operates the main valve by admitting the full initial pressure to the diaphragm chamber, causing it to close or open with a very slight change in delivery pressure,

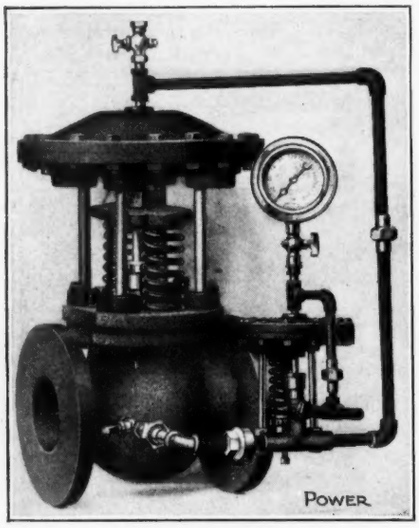


FIG. 5. REDUCING VALVE WITH AUXILIARY PILOT VALVE

regardless of variations in volume of delivery.

These valves are now used as relief valves between new installations of high-pressure boilers and old low-pressure

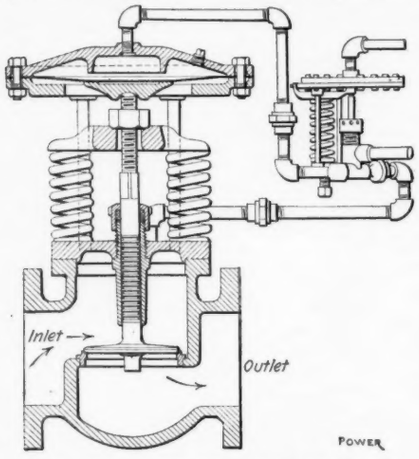


FIG. 6. SECTION OF THE PILOT VALVE TYPE OF REDUCING VALVE

boilers, in such manner that any surplus of steam from the high-pressure system will discharge into the low-pressure system, thereby helping to supply any deficiency in the low-pressure boilers. Valves for the last named purpose are of the same construction as those for reducing purposes except for a slight difference in the construction of the auxiliary valve.

The Pennsylvania Railroad System paid $180,577.73 to employees in July. Since the establishment of its pension fund, $33,704,578.25 have been paid out.

Smokeless Combustion of Coal

BY W. B. WILKINSON

To insure as near perfect combustion of bituminous coal as possible, 4 lb. of oxygen must be supplied to the burning fuel to successfully burn the escaping carbon. With the ordinary method of supplying air from the atmosphere, at the temperature of the boiler room, through the ashpit doors under the grate, only about 1 lb. of oxygen is supplied to the burning fuel after passing up through the body on the grates; consequently only one-fourth of the carbon is ignited and burned; the other three-fourths escape in the form of free carbon or black smoke with the gases escaping to the chimney. The problem is therefore to supply the necessary amount of oxygen to the coal. If an additional amount of air is blown in the ashpit by a fan, it is not evenly distributed to all parts of the burning fuel, especially in case of grates having air spaces for burning hard coal; consequently holes are burned through the fuel bed in spots, and a larger part of the oxygen escapes without coming in contact with the carbon. There is also the waste of energy expended in producing the forced draft.

The velocity by which the air is forced into the furnace also prevents it from being heated or raised to a temperature to free the oxygen from the nitrogen. It is, therefore, apparent that to get the best results the required excess of oxygen must be supplied in some way to the combustion chamber over the burning coal, and at a temperature so high that on its injection into the furnace the oxygen will be dissociated from the nitrogen. This requires that the air should be raised to a temperature of about 400 to 500 deg. F., so that upon entering the furnace where the temperature is much higher, the oxygen will be free to ignite the free carbon escaping from the coal.

The problem is where and how to introduce this heated air so as to mingle with the burning coal and escaping carbon, which, being of a higher specific gravity, is rapidly drawn away from the fire bed by the chimney draft and must be retarded and made to mix with the oxygen.

One method is to use a fan to supply air under an automatically regulated pressure, both under and over the fire, through conduits of suitable size, with discharging ports at regular intervals under the grate, and also distributing air over the fire or into the furnace at a point to meet the escaping carbon and gases before they pass to the combustion chamber. The air supply can be heated by contact with the steam used in operating the fan and also by passage through conduits which are heated by contact with or reffected heat from the incandescent coal and burning gases.

With a given boiler or a power plant where the boilers are sufficiently large to do the work required, good draft, good quality of coal, with shaking grates of the right size to burn the coal properly, so as to keep the fire bed clean and moderately low, and where intelligent firemen are employed, the foregoing method of supplying air to the furnace will meet all requirements necessary to burn bituminous coal without objectionable smoke, and will show great economy over ordinary or natural conditions.

Many prefer to burn soft coal with the primary advantage of obtaining more power from the boiler or increased evaporation capacity when the boilers are overloaded or when the draft is defective. In such cases another element is needed to change the chemical condition of the furnace to obtain a higher temperature of the gases passing through or around the boiler tubes and so insure a higher rate of evaporation. This element can best be supplied by hydrogen gas formed from superheated steam injected into the furnace under regulated pressure, operating automatically so as to avoid waste when not required.

A certain amount of steam supplied by the fan engine mingles with the air, but it is not enough for all requirements; therefore a steam superheater retort can be placed in the brick wall over the fire-door arch. This retort could be perforated at intervals with holes of proper size, and the steam jets ejected into the fire chamber so inclined as to give the best results in accord with the conditions of draft, coal used and the requirements of the boiler. Steam itself does not enter the fire chamber to the detriment of the brick walls, grates and boiler shells, but is superheated to a degree necessary to separate the hydrogen when ejected into the furnace. The hydrogen, as a new and additional element, naturally aids the evaporation capacity of the flue gases by adding additional heat units, the thermal equivalent of hydrogen gas being double that of coal gases.

Thus the conditions required to completely prevent any objection from the use of soft coal is provided, but as no two boilers ever operate or steam alike, so no two adaptations of the apparatus can be made alike. Each equipment must be made to meet the individual requirements, necessitating careful study of the plant to be equipped.

The amount of economy, prevention, etc., depends not on the equipment altogether, but also on the ability of the men in charge to operate it properly after it is turned over to them. If they have faith in it and will follow instructions and profit by experience, they will get better results day by day. If equipments are made for smoke prevention, a few

trials will prove the results by observation. Increased draft, increased power and economy of coal can be determined by evaporation tests or by comparison with previous records.

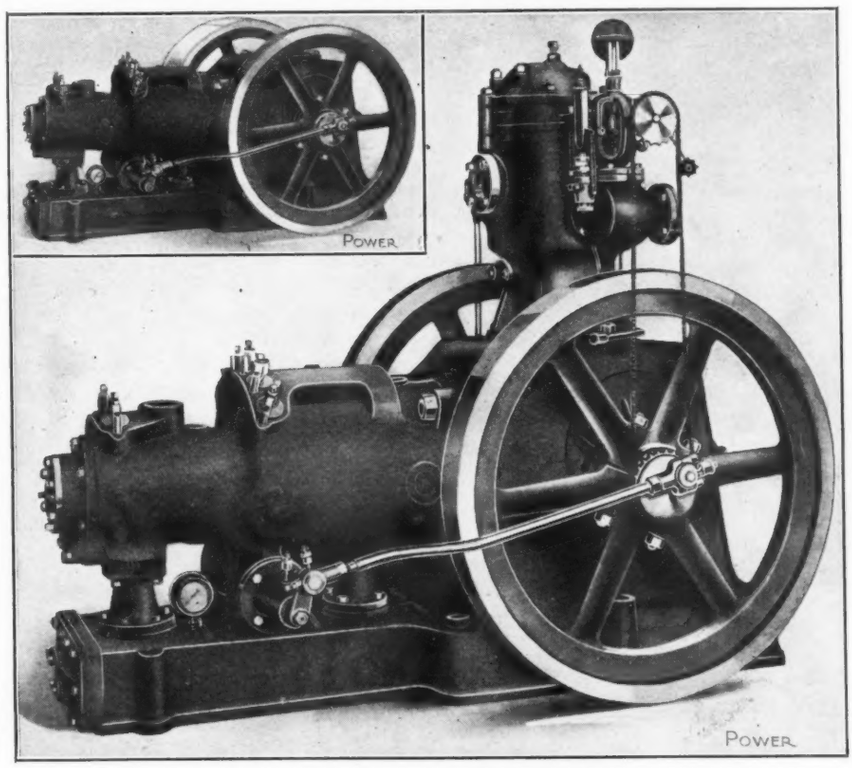
Barr Unit Compound Compressor

Four types of air compressors, built by the Pennsylvania Pneumatic Co., Erie, Penn., are shown herewith. They are made steam, belt and motor driven, with single and twin cylinders.

In Figs. 1 and 2 are shown single-plate. Both steam and air cylinders are accessible independently and are made single acting and fitted with a one-piece trunk piston. The air cylinder combines a high- and low-pressure bore and compresses in two stages.

The intercooler is of the sectional type with hollow water-cooled units of cast iron. It is located in the bed extension.

A balanced, double-ported, quick-opening steam valve is located in the cylinder head, which is steam jacketed. The steam and air valve-gears are outside connected. The discharge valves are of the one-piece cushioned type.



FIGS. 1 AND 2. SINGLE STEAM AND BELT DRIVEN COMPRESSOR

cylinder, belt and steam driven compressors, the latter being of the angle type width the steam cylinder set at right angles with the air cylinder. Figs. 3 and 4 show a twin, belt-driven, and a single motor-driven compressor, respectively.

The cylinders are supported by a heavy inclosed bed, also the crankshaft bearings. The bed is provided with a cover

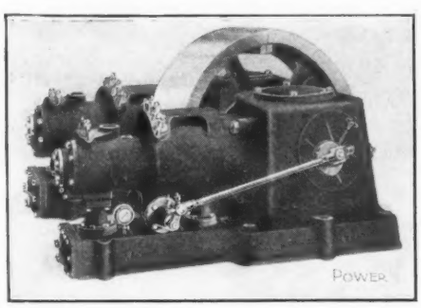


FIG. 3. TWIN BELT DRIVEN COMPRESSOR

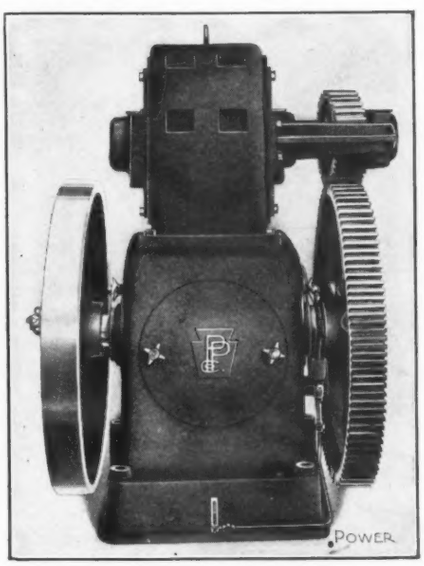


FIG. 4. SINGLE MOTOR DRIVEN COMPRESSOR

Teaching Engineering in Turkey

Under the direction of Prof. John R. Allen, Robert College, in Constantinople, has added an engineering department. It will chiefly be developed along mechanical and electrical lines, including water-power developments and irrigation, says the Newark *Evening News*.

The first wing of the new building under construction will be 56x115 ft. and four stories high. The forge shop will have down-draft forges blown by an electric fan, and a cutoff shear and punch. The foundry will be on the second floor. The cupola will be in the court and have a spout entering the foundry room. This room will be arranged for both floor and bench molding and equipped for making brass castings as well as iron. On the third floor will be the machine shop, with an engine lathe, a gap lathe, speed lathe, drill press, large planer shaper, milling machine, including all necessary tools and attachments, each group-driven electrically.

Power will be obtained from a central power house. The boiler house, now under construction, will contain two 150-hp. boilers, with room for a third to be installed later. These boilers will furnish steam for the electric lighting engines and for the heating.

The east wing of the engineering building will be the same size as the west or shop wing, and contain the power plant and experimental steam, electric and hydraulic laboratories. The first floor will be used for the power plant. Machinery will be available for instructing students in the operation and testing of a power house. On this same floor will be the larger gas engines and the hydraulic laboratory.

In the basement will be the feed pumps and condensing apparatus. The second floor forms a gallery for the first floor. The smaller gas and gasoline engines, the experimental electric motors and generators will be placed on this gallery. The third floor will be devoted to the calibration of instruments, computing rooms, special laboratories and offices. On the top floor will be drawing rooms, lecture rooms, museum, library and recitation rooms. This building will be built as soon as the growth of the department makes it necessary.

In addition to the strictly engineering work, it is proposed to establish classes in manual training for the younger boys. This will stimulate their interest in mechanics, besides giving them some knowledge of the manufacturing processes. The woodworking and pattern department on the fourth floor will contain a planer, a surfacer, a rip and crosscut saw, band saw, two speed lathes, a universal trimmer and a molding and mortising machine. Each machine will be driven by its own motor.

The First Electric Light Plant

Sept. 4 was the thirtieth anniversary of the beginning of commercial incandescent lighting. In 1882, Thomas A. Edison placed in operation in New York the world's pioneer central station.

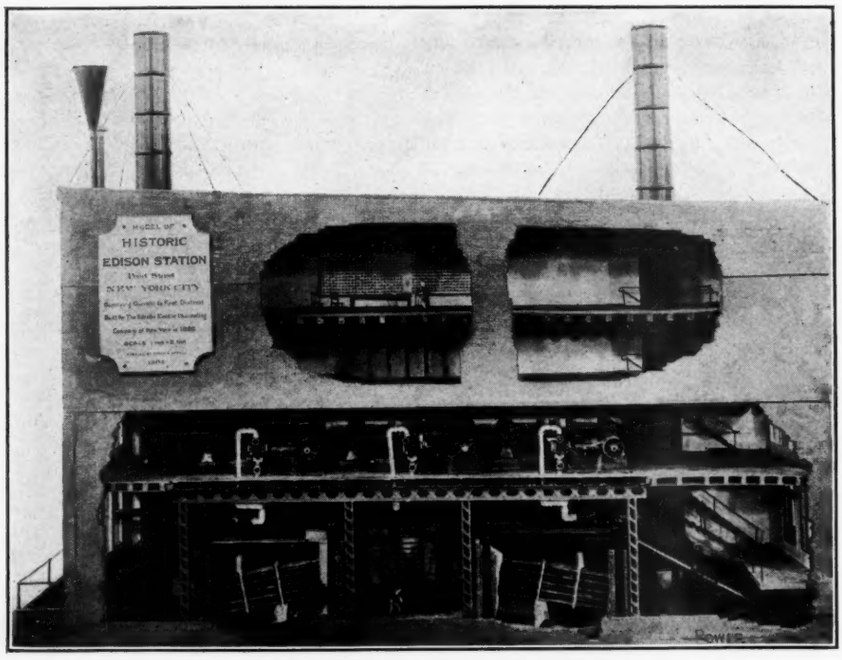


FIG. 1. MODEL OF THE FIRST LIGHTING PLANT

From a single generator of 125 hp. in an old brick building in lower Pearl St., current was sent through a system of underground cables to some 400 lamps in a territory about a mile square. With only two interruptions of less than 12 hours the service has continued until it now extends from the Battery to Yonkers, includes about 1300 miles of underground transmission lines and feeders, supplies 129,000 customers and has the equivalent of 11,000,000 lamps.

Instead of the old brick building that housed the generating apparatus there are now two structures covering two city blocks, while 31 substations are required to convert the high-tension transmission voltage to the low voltage for distribution; and the historic "jumbo" of 125 hp. has yielded ground to a 30,000-hp. steam turbine.

The Edison company of today is the successor of the company that under the personal direction of Mr. Edison established the world's first permanent central station. Two years of preliminary work saw the establishment of a steam-generating station, the extension of a distribution system of some 15 miles and the installation of about 400 incandescent lamps. This system now has 1300 miles of cable, 360 of which are of the high-tension transmission system, while from 400 incandescent lamps there are about 5,250,000, the connected load equaling 714,000 hp.

Steam boilers were installed in the basement of the reconstructed building at 257 Pearl St. and the six generating units, each driven by a 125-hp. engine, were set up on the second floor. These were the now historic "jumbos," the first type of commercial generating machines in the world.

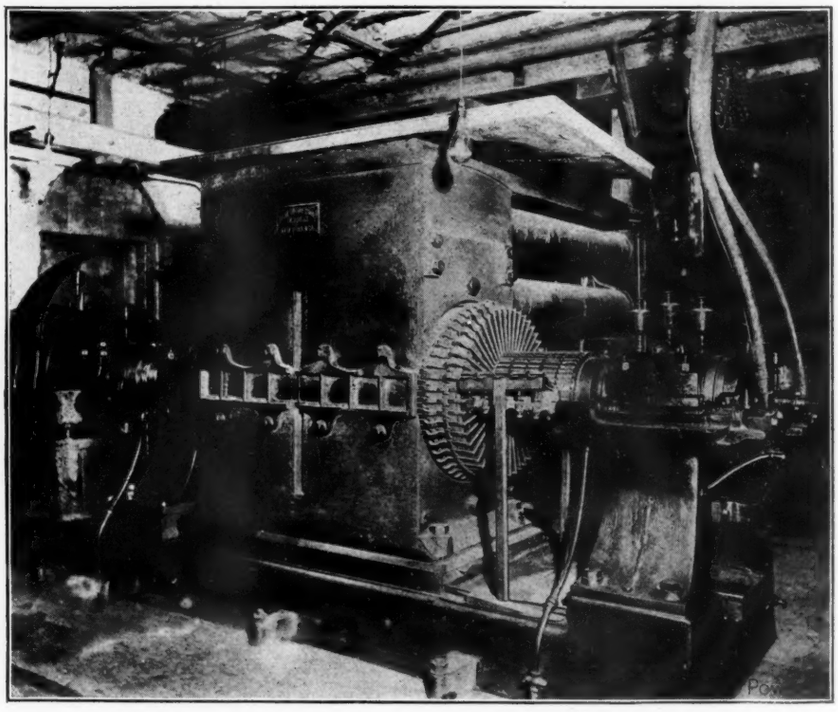


FIG. 2. ONE OF THE OLD-TIME "JUMBOS"

During the summer of the same year the underground distribution system was laid out and the wiring installed in the buildings of prospective customers. The wiring, laying the street mains and installing the generating apparatus were all done under Mr. Edison's personal supervision.

At 3 p.m., Sept. 4, the current was turned into the mains and to the buildings of the "first customers." A New York paper said at the time: "The Edison central station was yesterday one of the busiest places downtown and Mr. Edison was by far the busiest man in the station. According to Mr. Edison, they will go on forever, unless stopped by an earthquake."

On Jan. 2, 1890, fire destroyed the building. Only one dynamo, No. 6, was saved. That fire put the lighting system out of business for less than half a day, because the Liberty St. annex, opened in 1887, was able to take up the load, and by placing certain restriction on the use of current, carry the burden until new machinery could be installed at Pearl St. In 1890 another annex to the Pearl St. station was opened in the Produce Exchange Building.

In the meantime the new Duane-Pearl St. station, the fourth built to meet the increasing demand, had been completed, and in 1895, the old station was dismantled and sold. Old No. 6 (Fig. 2) is now treasured by the New York Edison Co. as a relic of the early days of the lighting industry.

The Waterside stations, built in 1900 and 1905, are the largest generating sta-

tions in the world, occupying two city blocks on the East River front and having a capacity of approximately 700,000 hp. They light 5,245,000 incandescent lamps, 40,400 arc lights on the system and supply 337,200 hp. in motors, while 159,000 meters are required to measure the current.

Although the Edison was the first organized company to do commercial electric lighting, there were earlier instances of incandescent lighting, all based on the inventions of Mr. Edison. At his home in Menlo Park he had an underground system supplying over 400 lamps. In 1897 a lighting system had been installed on the steamship "Columbia," while less than a month prior to the opening of the Pearl St. station a small generator of a different type was placed in operation at Appleton, Wis., where a waterfall supplied the power.

Non Bypass Valve for Large Steam Lines

BY F. E. SANBORN

Steam engineers and others having to do with large steam lines will be interested in a valve which is being used in England. In this country it has been customary to use a large, heavy and consequently expensive valve of the size of the pipe in which it is placed. On such a valve is a bypass with its valve.

The valve now used in England is deserving of consideration. Its flanges are for the size of pipe used, but the run of the valve is shaped something like a Venturi meter. The valve gate is placed in the constricted part and is shown in its closed position in Fig. 1.

When the gate is raised by the handwheel a ring is brought up from below, filling the space in the metal and forming a smooth passage for the steam, as shown in Fig. 2. For pipe sizes up to and including 12 in., no bypass is needed to equalize the pressure in order to open the valve. For sizes above 12 in. a bypass is used.

The advantages of this valve include less cost, the expense being from 50 to 65 per cent., including duty, of that for the American bypass valve, outside stem and yoke; less leakage, as the perimeter of the valve disk and seat is about one-half as long; protection of seats when steam is flowing; smooth passage for steam and so fewer eddies in the current; less work in opening and closing the valve; and less weight.

The valve body may be had in cast iron or cast steel. The valve seats and disks are of a special metal as hard as nickel-steel, and are renewable. These are suitable for use with superheated steam.

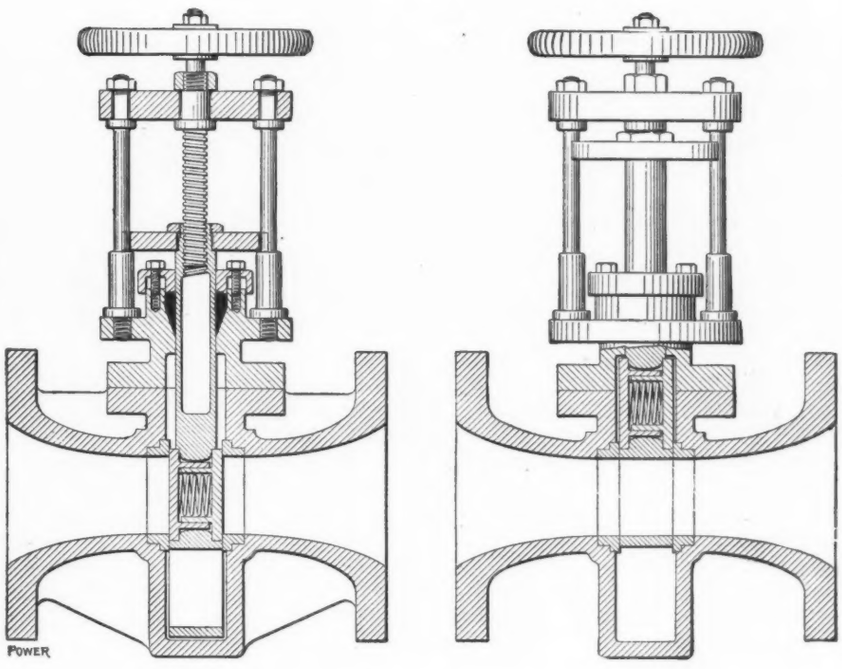


FIG. 1 FIG. 2

NON BYPASS VALVE FOR LARGE STEAM LINES

Inquiries of several users of the valve in England developed the fact that it was giving satisfaction. It seems to be little, if at all, used in this country and yet is a valve with which an uptodate steam user or engineer should be familiar.

The National Association of Stationary Engineers Convention

The thirtieth annual convention of the National Association of Stationary Engineers was held at Kansas City during the week commencing Sept. 8. Notwithstanding the distance of the convention city from the geographical center of the membership and from the numerous Eastern supply houses, the occasion brought together 370 delegates from all over the United States and some 150 establishments took part in the exposition, which has become a feature of these conventions. Their representatives with the families and guests of the delegates brought the total attendance to upward of 1000.

The sessions were held in the New Casino, a hall of generous proportions almost contiguous to the headquarters hotel. The spacious hall, built for the Democratic National Convention of 1900 and but a few blocks removed furnished an ideal place for the exposition.

On Monday evening an informal reception in the parlors of the Coates House gave an opportunity for the renewal of old and the making of new acquaintanceships. A concert by Hiner's Band was an enjoyable feature of this and other evenings.

The opening session of the convention was called to order at 10 o'clock on Tuesday morning by W. F. Groom. chairman of the local committee, and after an invocation by the Rev. E. B. Olmstead, Mayor Henry L. Jost, of Kansas City, welcomed the delegates, and National President Edward H. Kearney responded. Addresses of welcome were also made by ex-Senator J. K. Cubbison and John H. Atwood with responses by National Vice-President John F. McGrath and Past National President Carl S. Pearse.

At the close of the opening exercises the audience proceeded to Convention Hall where the exposition was formally opened by Vice-President McGrath.

PRESIDENT'S ADDRESS

The address of President Kearney dealt at length with the educational work of the association. The previous convention had authorized him to appoint a committee to report at this convention a "Plan of Education." He could not brook a year's delay and appointed the committee consisting of Professors Edward F. Miller and Joseph C. Riley, Massachusetts Institute of Technology, and John W Lane, editor of the official organ of the association, and authorized the immediate establishment of a course of instruction under their direction. He recommended establishing a permanent educational board to develop a system which may be amplified and extended from year to year. He suggested also

an information bureau to which members might turn when in need of information "such as is sold at prohibitive prices by consulting engineers."

He believed that energetic and concerted action by individuals and associations will do more for the passage of license laws than the lavish expenditure of money.

State associations are here to stay and must be recognized as an all important factor in the work which the National Association is carrying out. "Let us hope," said he, that from year to year state associations will continue to gain in membership and importance and that their task will not be considered as complete until a staff of lecturers has been provided to meet the requirements of subordinate associations and a license and boiler-inspection law has been enacted in every state where there is none in existence."

He recommended compiling and publishing a history of the association.

Reports

National Deputy John F. McGrath reported that during the year 2085 members had been added to the association, 1035 members had been lost, leaving a net gain of 1050 and making the present membership 19,054.

C. H. Wirmell, chairman of the license committee, told of the efforts made in New York, Delaware, Kentucky, Maryland and Michigan to secure license laws with defeat all along the line. He attended the meeting of the Commission on Uniform State Laws in Milwaukee, and, with a representative from the American Boiler Manufacturers' Association, presented a brief covering the essential reasons for uniform laws relating to boiler inspection and the licensing of engineers, which was referred to a committee to report on at the next conference.

Prof. Riley, reporting for the Educational Advisory Board, said that in December a series of articles was printed in the official organ of the association calling attention to the desirability of studying operating costs in power plants. Subordinate associations were invited to arrange their programs so that each month a different type of plant could be discussed and questions appearing in the *National Engineer* be answered by the members. Cash prizes were offered dealing with operating costs in power plants of any type. Other prizes were offered to associations for similar papers embodying their joint opinion.

No response was received from any association to this invitation, but a number of individual papers, some of a high order of merit, were received.

The first prize, $125, was won by George F. Wheaton, of Rhode Island No. 2, for a paper dealing with power costs in textile mills.

The second prize, $75, went to E. S. Clark, of Ohio No. 1, for a paper dealing with the cost of producing power in a paper mill.

The third prize, $50, was awarded to R. L. Ellis, of Alabama No. 1, for an essay upon the general subject of power-plant costs.

The fourth prize, $25, was won by Norman S. Campbell, of Michigan No. 1, for a paper on the cost of hydraulic and electric-elevator systems.

G. L. Finch, of Massachusetts No. 14, received honorable mention.

Slide-rule classes were advocated and several were formed. Prizes in the form of slide rules to the amount of $137.50 were awarded.

Prizes of $50, $25, $15 and $10 were awarded respectively to the Illinois, Wisconsin, Colorado and Iowa state associations for the best convention programs from the educational standpoint.

The committee believes that the proper place for the educational work to be done is in the local associations and recommends that the national association assist these associations by publishing in the society's organ, lists of questions for discussion, furnishing lantern slides for illustrated lectures, etc.

Prof. Riley also delivered a lecture illustrated by lantern slides on the "Action of Gas in the Gas Engine," and C. R. Foster, of the Buckeye Electric Co., of Cleveland, one on "Modern Factory Illumination."

The convention passed with enthusiasm a resolution presented by Thomas W. Roberts, Cleveland, pledging the moral and financial assistance of the association to engineers, who were opposing unjust encroachments and discriminations by the central station, whether for light, power or heating.

The Life and Accident Department has a membership of 3272. Amendments requiring a medical examination were passed. J. D. Taylor was reëlected secretary-treasurer.

The mileage of the delegates to Kansas City cost the association $17,134.10. The convention authorized the formation of district associations and in view of the growing importance of state associations and the increasing cost of the national convention appointed a committee to consider and report upon the advisability of making the conventions of the national association biennial.

Results of Elections

The officers elected were: John W. McGrath, Chicago, president; James R. Coe, New York, vice-president; Fred Raven, Chicago, secretary; Samuel B. Forse, Pittsburgh, treasurer; William J. Reynolds, Hoboken, trustee; George A. Camblin, Denver, conductor; F. W. Fisher, Knoxville, doorkeeper.

The National Exhibitors' Association elected the following officers for the ensuing year:

M. B. Skinner, president; Homer Whelpley, vice-president; Henry A. Pastore, secretary; J. M. Chapman, treasurer; John H. Foote, Harry D. Raymond, Charles A. Wilhoft, Paul Payne and Charles Cullen, members of the executive committee.

The Ladies Auxiliary elected the following officers:

Mrs. Alice Heckler, president; Mrs. Sophia Moran, vice-president; Mrs. Margaret Flinn, secretary; Mrs. Emma M. Stone, treasurer; Mrs. Emily A. Dill, chaplain; Mrs. Fred Felderman, conductor Mrs. Gertrude Hunt, doorkeeper.

The program for the entertainment of the convention comprised a reception by the Ladies Auxiliary at the Coates House with an entertainment under the direction of Laura Valworth Hull Tuesday

The Exhibits at the N. A. S. E. Kansas City Convention

evening; a picnic at Fairmount Park Wednesday afternoon and evening; an entertainment by the National Exhibitors' Association Thursday evening, and a ball Friday evening. Special entertainment, including automobile rides, was provided for the ladies. The usual presentations were made to the retiring presidents of the N. A. S. E., the Exhibitors Association and the Ladies Auxiliary and to the chairman of the local committee, and the usual votes of thanks were passed, in this case exceptionally well merited for the attentions received and hospitality enjoyed.

The next annual convention will be held at Springfield, Mass., the second week in September, 1913.

[We regret that failure to receive the photograph prevented our having the usual view of delegates and visitors.—EDITOR.]

EXHIBITORS

Following is a list of those who had space in Exposition Hall:

Albany Lubricating Co., American Steam Gauge & Valve Manufacturing Co., The Anchor Packing Co., V. D. Anderson Co., Armstrong Cork Co., Arrow Boiler Compound Co., The Ashton Valve Co., Builders Iron Foundry Co., Bishop, Babcock, Becker Co., Bowers Rubber Works, S. F. Bowser Co., Inc., Buffalo Forge Co., Central Coal & Coke Co., A. W. Chesterton Co.. The Chapman Valve Manufacturing Co., Clement Restein Co., Cling Surface Co., Consolidated Engineering Co., Crandall Packing Co., Dearborn Drug & Chemical Works, Diamond Power Specialty Co., Joseph Dixon Crucible Co., Durabla Manufacturing Co., Economy Fuse & Manufacturing Co., Elliott Co., The English Tool & Supply Co., The Fairbanks Co., Falls Machine Co., Fisher Governor Co., Flexitallic Gasket Co., France Packing Co., Garlock Packing Co., Greene, Tweed & Co., Gustin Bacon Manufacturing Co., Harrison Safety Boiler Works, Hawkes Boiler Co., Hawkeye Compound Co., Heine Safety Boiler Co., Hill Pump Valve Co., Hills McCanna Co., Homestead Valve Manufacturing Co., Howe Rubber Co., Illinois Malleable Iron Co., The Imperial Brass Manufacturing Co., International Correspondence Schools, Jenkins Bros., H. W. Johns-Manville Co., Kansas City Engineering Co., Kansas City Rubber & Belting Co., Kent Lubricating Co., Keystone Lubricating Co., Lagonda Manufacturing Co., A Lescher Sons, Liberty Manufacturing Co., Lunkenheimer Co., Mason Regulator Co., The Mayer Coal Co., McCord Manufacturing Co., James McCrea & Co., McLeod & Henry Co., W. B. McVicker Co., *Mining & Engineering World*, Missouri Fidelity & Casualty Co., Morehead Manufacturing Co., Murray Iron Works, *National Engineer*, The New York Belting & Packing Co., Nicol Smokeless Grate Co., Ohio Blower Co., The Ohio Brass Co., Ohio Grease Lubricating Co., Ohio Injector Co., Otis Elevator Co., Palmer Forced Draft Slack Burner Co., Peerless Rubber Manufacturing Co., Penberthy Injector Co., The Perolin Co. of America, Peterson Engineering Co., Philadelphia Grease Manufacturing Co., POWER, *Practical Engineer*, Quaker City Rubber Co., Reeves & Skinner Machine Co., Revere Rubber Co., Richardson-Phenix Co., Ridgway Dynamo & Engine Co., John A. Roebling's Sons Co., Rogers Metal Works, Rosedale Foundry & Machine Co., Schaeffer & Budenberg Manufacturing Co., *Southern Engineer*, C. E. Squires Co., Standard Oil Co., Standard Regulator Co., Strong, Carlisle & Hammond Co., Under-Feed Stoker Co. of America, United States Graphite Co., Western Boiler Compound & Chemical Co., Western Tire & Rubber Co., Westinghouse Air Brake Co., Westinghouse Machine Co., White Star Refining Co., The Williams Gauge Co., Yale & Towne Manufacturing Co.

Joint Meeting of Engineers in Germany, 1913

Elaborate preparations are in progress for the entertainment of the American Society of Mechanical Engineers on its visit to Leipzig, Germany. to meet with the Verein deutscher Ingenieure in June of next year. While it is early to announce the features of the program, it may be said that the attractions include a reception at Hamburg by the senate, another by the Hamburg-American Line, and a visit to the shipyards of Blohm & Vose, the largest shipbuilders on the continent, where an opportunity will be offered to inspect the "Super-Imperator," the largest steamship yet under construction, and to see Diesel engines of 6000 hp. each, 2000 hp. being developed in one cylinder.

The party will then be taken by special train to Leipzig, where it will be received by the King of Saxony and the first of the professional sessions will be held. A paper is promised by Prof. Lamprecht, of the University of Leipzig, the famous historian, one by Dr. C. Matschoss, probably on the history of engineering, and another by Prof. Busley on aërial navigation. It is hoped that Count Zeppelin will be present with one of his dirigible balloons. There will also be a concert by the famous Gewandhaus orchestra under Nikisch, the most famous living conductor in Europe. While the party is in Leipzig, the dedication of the monument erected in commemoration of the battle of Leipzig 100 years ago will take place. The next stop will be at Dresden, where the castles, galleries and technical high schools will be visited. From here the party will proceed to Berlin, where the program will comprise an excursion through the castle of the Kaiser at Pottsdam, a great lake festival at Wannsee, and a reception at the Zoological Gardens, as well as visits to the Allgemeine Electricitäts Gesellschaft, Borsig, Ludwig-Lowe, Siemens-Schuckert and others. A special train will then be taken to Essen, where the party will be received by Krupp von Bohlen, the president of the Krupp works, and exceptional facilities will be given to see the latest processes in steel manufacture, etc. A visit is also planned to the Krupp works at Rheinhausen, which are the finest steel works in Germany, and an opportunity will be afforded to inspect the entire process from the raw material to the finished product. At Düsseldorf the party will be received by the iron and steel institutes, and at Cologne by the city authorities, the reception in the latter city being held in the famous Old Guild Hall. From Cologne visits will be made to the establishment of Deutz, Humboldt. From Cologne the party will go up the Rhein by steamer to Rüdeschim, where a festival will be held on the banks of the river. At Heidelberg an illumination of the castle is promised. At Mannheim, visits will be made through the shops of Sulzer Bros., Lanz, and Brown Boveri. The party will then proceed to Munich with a possible stop at Nürnberg. At Munich the professional sessions will be continued in the famous industrial museum, and there will be receptions by the city and by the Prince of Bavaria.

Discontinuing the Power Plant

One of the present-day results of electric transmission, especially in large towns and cities, is the offer of electric-power people that tempts the machine woodworker, along with other users of power, to discontinue the power plant and buy current. There is perhaps more hesitancy on the part of woodworkers than anyone else, as they make a certain amount of shavings and dust and thus have fuel for making their own steam power. Yet many mills and factories are cutting out their engines and buying current.

Whether or not anyone should, depends materially on the cost, and the matter of having fuel should be looked at from both sides. Some fuel will be needed anyway, for drying and heating purposes. This, in some plants, will take care of the dust and shavings, and much of the other scrap may be sold for kindling. Some woodworking institutions that have never installed engines of their own, have a boiler for the drykiln and for heating the plant during the winter, and for other uses calling for steam. The dust and shavings are piped to it, a moderate steam pressure is maintained with but little firing trouble, and they get along very nicely. Others have cut out the use of their engines, but retain a little fire under their boilers in the same way. It is compara-

tively easy to do this and try the effect, and it is especially tempting when the engine runs down, gets too small for the work, or is too heavy a tax on the boilers.

Taking it altogether, the way the wind blows now, it looks like the discontinuation of lots of woodworking power plants. Some of large size have already swung over, even if they do have shavings and dust. They use it for the drykiln and heating, and perhaps figure on cleaning up their waste closer than they once did, and selling the balance for kindling.—*The Woodworker.*

To Succeed Long Acre Co.

It has been announced that the Intercity Power Co., of New York City, which was recently incorporated under the laws of Delaware, will take over the entire franchise, property and assets of the Long Acre Electric Light & Power Co. It is also reported that the new company proposes to furnish lighting and motor service throughout Greater New York and will enter into an agreement with the Hudson & Manhattan R.R. Co. to receive all of the latter's surplus electrical energy. No details have yet been announced.

Three Gas Tanks Explode

The explosion of three gas tanks at the A. O. Smith Co. plant, at Milwaukee, Wis., on Aug. 26, killed one employee and injured six others. The tanks stored acetylene gas for welding. The pressure at the time of the explosion was 40 lb. It is believed the gas was ignited by a flashback from a welding torch.

Power House Collapses

Early in the morning of Sept. 8, the old power house of the No. 4 mill of the Lonsdale Co., Lonsdale, R. I., slid into the mill trench, dragging with it a portion of the five-story brick building with which it was connected and causing damage estimated at about $75,000.

The accident came without warning and was evidently caused by the undermining of the foundations. When the power house dropped, a large section of the adjoining building was wrecked. Had the accident occurred a few hours later, when the mill would have begun work, 75 of the power-house employees might have been crushed in the débris. About 600 employees will be out of work until the necessary repairs are made.

The collapse is believed to have been due to the undermining of the big waterwheel, which has furnished part of the mill power during the last two generations. The walls of the wide trench are made of stone, and beneath the power house the waterwheel has rested on these. It is thought that they gave way, releasing the supports at the end of the building.

BOOKS RECEIVED

MACHINE DESIGN. By H. D. Hess. J. B. Lippincott Co., Philadelphia, Pa. Cloth; 364 pages, 5¼x9 in.; 318 illustrations; tables; indexed. Price $5.

SHOP ARITHMETIC. By E. B. Norris and K. G. Smith. McGraw-Hill Book Co., New York. Cloth; 187 pages, 6x9 in.; 86 illustrations; tables; indexed. Price $1.50.

TEXTBOOK OF THEORETICAL NAVAL ARCHITECTURE. By Edward L. Attwood. Longmans, Green, and Co., New York. Cloth; 518 pages, 4¼x7¼ in.; plates; tables; 145 illustrations; indexed. Price $2.50.

NEW PUBLICATIONS

HOUSE WIRING. By Thomas W. Poppe. Published by The Norman W. Henley Publishing Co., New York, 1912. Size 4x6 in.; 100 pages, illustrated. Price 50c.

A little book devoted exclusively to describing and illustrating the methods of installing electric-light wiring and fixtures in modern office buildings and dwellings. It is thoroughly practical in character and, being intended primarily to aid the electrician and helper, no attempt has been made to cover the field of the illuminating engineer; only the simplest problems being given in laying out a lighting system.

THE STEAM TURBINE; Revised fourth edition. By Robert M. Neilson. Published by Longmans, Green & Co., London. Cloth, 651 pages; 9½x6 in.; illustrated. Price, $5, net.

It has been stated that the design and construction of the steam turbine is practically standardized, yet the appearance of new and enlarged editions of the well known manuals of steam-turbine practice has not ceased.

The fourth edition of Robert M. Neilson's "The Steam Turbine," although published as lately as 1908, has now been reissued with additions, increasing its value to a considerable extent. The new matter consists of an extension of the list of patents to include all British patents up to the end of 1909 and an appendix of 35 pages in which the author summarizes the "most important developments" in the last four years.

Mr. Neilson gives considerable space to the combined impulse and reaction type which so many turbine builders have adopted as their standard practice, but naturally puts emphasis on the later developments of the marine turbine, the geared turbine and the "recipro-turbine" in marine work. On page 630 he gives a most interesting set of curves on steam consumptions of modern turbo-generators, which he says are "unlikely to be surpassed to any great extent in the future."

The power-station reproductions are well chosen and valuable.

PERSONAL

F. G. Clark, of New York, has accepted a position as chief engineer of the Toronto Electric Light Co.

J. Albert M. Robinson, formerly engineer of the Brown Portable Elevator Co., is now hydraulic engineer for the American Well Works, First National Bank Building, Chicago.

B. A. Brennan has resigned as sales manager of the power department of the Bethlehem Steel Co. to accept the office of manager of the corporation department of the Mercantile Trust Co., of St. Louis. He began his new duties Sept. 10.

Francis F. Longley has been admitted to partnership in the firm of Hazen & Whipple, consulting civil engineers, New York. Mr. Whipple, who last year became professor of sanitary engineering in Harvard University, retains his membership in the firm and is still open to professional engagements.

Dr. Conrad Matschoss, the European writer of notes on industrial history, historian of the Royal Polytechnic High School of Berlin, is visiting the United States as the official representative of the Verein Deutscher Ingenieure, with special reference to the arrangement for the visit of the American Society of Mechanical Engineers to Germany in June of next year.

Robert F. Pack, formerly general manager of the Toronto Electric Co., Toronto, has been appointed general manager of the Minneapolis General Electric Co. Since the resignation of A. W. Leonard, early in August, the position has been temporarily filled by Samuel Kahn, who will resume his duties in the operating department of H. M. Byllesby & Co. Gen. George H. Harries, vice-president of the Consumers Power Co., will continue to act in a supervisory capacity over all the properties of this corporation. Mr. Pack is president of the Canadian Electric Light Association and a member of the American Institute of Electrical Engineers.

SOCIETY NOTE

On Oct. 25, the National Association of Stationary Engineers will be 30 years old. The subordinate associations of Chicago are planning to hold an informal stag dinner on the evening of that date to celebrate the event and to tender a reception to John F. McGrath, the newly elected national president of the association, who is a member of Illinois No. 28. The following committee is in charge of the arrangements: Messrs. Raven (chairman), Lightly, Moore, Illinois, No. 1; Warren, Noward, Kleynstuber, Illinois, No. 2; Haydin, Barnhardt, Whyte, Illinois, No. 28; Tavernier, Bishoff and Anderson, Illinois, No. 38.

OBITUARY

DAVID M. FORKER

On Aug. 29, David M. Forker, vice-president of the D. T. Williams Valve Co., Cincinnati, Ohio, died at his home in that city at the age of 51.